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Interaction Design and Evaluation of Mobile Guides for the Museum Visit: A Case Study in Multimedia and Mobile Augmented Reality

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Interaction Design and Evaluation of Mobile Guides for the Museum Visit: A Case Study in Multimedia and Mobile Augmented Reality

Abstract: This thesis examines the context of use of mobile multimedia handheld guides and applications as an alternative interpretation medium in the museum environment. Its main research hypothesis is that the use of mobile Augmented Reality (AR) technologies and the AR metaphor as a principal component for the conceptual and interaction design of mobile museum guide applications could greatly facilitate interaction and navigation, both in the mobile multimedia application and in the sensitive museum ecology.

After examining the context of use of mobile multimedia museum guides, proposing a set of classification criteria, redefining the notion of interactivity in the specified research context and examining how AR technologies can shape already existing or future functional requirements, the main research hypothesis is tested through the design, implementation and evaluation of a mobile AR museum guide, conceived for a state Museum of Fine Arts (Musée des Beaux Arts), in Rennes, France. The evaluation methodology is then exposed, before carrying on to the evaluation of the AR guide. The latter, mainly qualitative in nature, included the use of direct and indirect observations, semi-structured interviews, questionnaires and two focus group sessions and shed light on several issues related with the potential but also the constraints of using AR technologies as an intuitive and easy to understand alternative for geolocalization and orientation in the museum space and the mobile multimedia application.

The topic treated appertains in the wider domain of Human-Computer Interaction (HCI) with mobile devices and services or Mobile Human Computer Interaction (MHCI). However, because of the specificity of the examined research hypothesis, the thesis also aims to contribute methodologically, but also empirically, in the current state of the art regarding the interaction, interaction design and evaluation of mobile AR applications. Finally, due to the nature of the domain-space in which the experimental interventions took place -the museum environment- the thesis also sheds light on the ways by which using mobile multimedia guides can alter, transform or enhance the museum visiting experience and the relations of contemporary museums with their public.

Keywords: mobile human computer interaction (MHCI), interaction design, Augmented Reality (AR), mobile museum guidance systems, museum, museum visit, interpretation media, multimedia, evaluation, museum handheld devices, mobile learning, visitor studies, evaluation, participatory design, edutainment

Etude d'Intéraction et Evaluation de Guides Portables Multimedia pour la visite culturelle: Des Multimedia à la Réalité Augmentée Mobile

Résumé: Cette thèse examine le contexte d'utilisation des guides portables multimédia comme aide alternative à la visite culturelle. Son hypothèse de recherche principal est que l'utilisation des technologies de Réalité Augmente (RA) mobile et de la métaphore introduit par la RA en tant que component principal de conception et d'interaction concernant les guides multimedia portables, pourrait énormément faciliter l'interaction et la navigation, tant dans l'application interactif mobile que dans le contexte sensible du musée.

Le domaine traité appartienne plus largement dans le contexte plus large de l'interaction Homme-Machine Mobile. Cependant, à cause de la nature du sujet traite, la thèse apporte aussi des éléments qui enrichissent l'état de l'art concernant l'interaction et évaluation des applications de RA mobile. Enfin, a cause de la nature de l'environnement ou l'expérience a eu lieu –le musée- la thèse apporte aussi des contributions sur les façons avec lesquelles l'utilisation des guides portables multimedia pour la visite culturelle peut altérer, transformer ou promouvoir l'expérience de la visite culturelle et les relations du musée contemporain avec ses publics.

Après avoir examiné le contexte d'utilisation des guides portables multimedia pour la visite culturelle, proposé un set de critères de classification, réexaminé la notion d'interaction dans notre contexte de recherche et investigué de quelle manière les technologies de RA pourraient former l'analyse conceptionelle et fonctionnelle des guides portables multimedia, l'hypothèse de recherche principal est testé a travers la conception, l'implémentation et l'évaluation d'un guide de RA mobile, créé pour et avec le Musée des Beaux Arts de Rennes. La méthodologie et le protocole d'évaluation sont ensuite exposés avant de venir aux résultats des sessions d'évaluation qui ont eu lieu dans l'environnement du Musée. Des observations ont été combinée avec des entretiens semi-structurées, suivis ensuite d'un questionnaire et deux sessions des entretiens de group. L'analyse de donnes a démontré plusieurs avantages mais aussi inconvénients lies avec l'utilisation de la RA comme un alternative intuitive et facile a utiliser pour la geolocalisation, l'orientation, la navigation et l'interaction tant dans l'environnement du musée que dans l'environnement de l'application interactive.

Mots-clés: guides portables multimedia pour la visite culturelle, interaction homme-machine (IHM) mobile, interaction, interactivité, Réalité Augmentée (RA), évaluation, multimedia, musée, visite culturelle, médiation culturelle, évaluation, apprentissage assistée par ordinateur, design participatif

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This work benefited from the continuous support of many "families" of individuals that I would like to thank here.

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Last, but certainly not least, comes my own family for its continuous and unreserved support. It is to my mother, my father, my brother and my beloved grandmother that I co-dedicate this work.

BRIEF CONTENTS

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF CHARTS

LIST OF TABLES

Famous Blue Raincoat

It's four in the morning, the end of December
I'm writing you now just to see if you're better
New York is cold, but I like where I'm living
There's music on Clinton street all through the evening.

I hear that you're building your little house deep in the desert
You're living for nothing now, I hope you're keeping some kind of record.

Yes, and Jane came by with a lock of your hair
She said that you gave it to her
That night that you planned to go clear
Did you ever go clear?

Ah, the last time we saw you, you looked so much older
Your famous blue raincoat was torn at the shoulder
You'd been to the station to meet every train
And you came home without Lily Marlene

And you treated my woman to a flake of your life
And when she came back she was nobody's wife.

Well I see you there with the rose in your teeth
One more thin gypsy thief
Well I see Jane's awake --

She sends her regards.
And what can I tell you my brother, my killer
What can I possibly say?
I guess that I miss you, I guess I forgive you,
I'm glad you stood in my way.

If you ever come by here, for Jane or for me
Your enemy is sleeping, and his woman is free.

Yes, and thanks, for the trouble you took from her eyes
I thought it was there for good so I never tried.

And Jane came by with a lock of your hair
She said that you gave it to her
That night that you planned to go clear

Sincerely,
L. Cohen

To “Jane”

PART A

«Calme, l'esprit lucide, je regarde le monde et je dis : Tout ce que je vois, entends, goute, sens et touche, est création de mon entendement. Le soleil monte et descends dans mon crane. Dans une de mes tempes se lève le soleil ; dans l'autre le soleil se couche»

Nikos Kazantzakis, Ascèse, Salvatores Dei

"It is only with the heart that one can see rightly; what is essential is invisible to the eye."

Antoine de Saint Exupéry, The Little Prince

CHAPTER 1

INTRODUCTION

1.1 SCOPE OF THE THESIS

This thesis examines the context of use of mobile multimedia handheld guides and applications as an alternative interpretation medium in the museum environment. Its main research hypothesis is that the use of mobile Augmented Reality (AR) technologies and the AR metaphor as a principal component for the conceptual and interaction design of mobile museum guide applications could greatly facilitate interaction and navigation both in the mobile multimedia application and in the sensitive museum ecology.

The topic treated appertains in the wider domain of Human-Computer Interaction (HCI) with mobile devices and services or Mobile Human Computer Interaction (MHCI). However, because of the specificity of the examined research hypothesis, the thesis additionally aims to contribute methodologically but also empirically in the current state of the art regarding the interaction, interaction design and evaluation of mobile AR applications. Finally, due to the nature of the domain-space in which the experimental interventions took place, the museum environment, the thesis also sheds light on the ways by which using mobile multimedia guides can alter, transform or enhance the museum visiting experience and the relations of contemporary museums with their public.

1.2 RESEARCH MOTIVATIONS

1.2.1 UNDERSTANDING MOBILE CONTEXTS

Mobile information and communication devices and services are spreading globally with a pace that has never been seen before, especially if one compares with the slower pace of adoption of office information systems. Initially conceived at the late 1970s and early 1980s in Japan and Scandinavia, mobile phones and telephony have undergone a considerable transition from a technology-focused professional tool to a show-off gadget and lately a mass-market consumer product adopted by hundreds of millions of people globally (Kiljander, 2004). Indisputably, currently, owning a mobile phone has largely become a norm as well as a social necessity, at least in western and developed societies.

The spread of mobile telephony and the change that everyday communications underwent in everyday life is not the only important change witnessed in the course of the last years. Together with the possibility of communicating with anyone, anywhere, anytime, other forms of communication and use of mobile devices and services started to emerge. The most illustrative example is provided by the largely unpredicted success of the short message service (SMS), currently one of the most widely used data applications on the planet (Baron et al., 2006), representing a massive industry reported to worth globally over 80 billion dollars in 2006 (ITU, 2006).

As storage and processing power capacities do not cease to evolve and the population gets more and more accustomed in owning, using and manipulating mobile devices, a large variety of other multimedia applications became available to such a degree that we are now facing the "convergence" phenomenon: the transformation of mobile phones to devices that can read and send mail, play music, store photographs, be used as playing platforms, provide navigation and way-finding assistance, act as video and audio recorders or even as e-wallets. For countries in the avant-garde of new technologies appropriation, like Japan, it has been argued that mobiles have become more important than house keys, serving not only for the consultation of digital content but also as a remote control for many other devices (Sukemoto, 2004).

A common parameter of all these developments is that, in most of the cases, it is the user needs as well as the users' patterns of behaviors that shape future directions for services, devices and products and not just simply the industry (Harper, 2003). The possibilities seem still very rich and diverse as, despite the remarkable advances in mobile computing, there are still target groups (like for example senior citizens (Love, 2005) as well as types and contexts of applications that just start to get explored.

At a time where our contemporary knowledge society sets new requirements for training and education with an accentuated emphasis on lifelong learning, one of the least explored and most promising challenges regarding mobile computing is to understand how mobile and tangible devices and technologies can be used in order to better support learning (Vavoula and Karagiannidis, 2005). Mobile learning has the potential to adapt to the learner's preferences and capabilities and to accompany learning not only in formal but also in informal learning environments seamlessly and discretely, featuring new, engaging and interactive activities (Naismith et al., 2006). The New Media Consortium (NMC), an international not-for-profit consortium regrouping nearly 300 learning-focused organizations has since 2006 consecrating parts of its annual "Horizon" report in the ways mobile technologies can be used to enhance on-site, collaborative and interactive learning in formal and informal learning environments (NMC, 2009).

Within this scope, the introduction and use of mobile audio and multimedia guides in the museum environment can be considered as a distinct category of mobile, interactive and multimedia edutainment application. The next section focuses on the particularities of the context in which the PhD Thesis interventions and experimentations took place, the museum environment.

1.2.2 MUSEUMS AND THE INTERPRETATION OF CULTURAL HERITAGE

The last decades have seen museums all over the globe literally re-inventing themselves (Valance, 2007). Since the 1970s, the western industrialized world has been witnessing a "boom" both in relative museum numbers but also in terms of role and influence exercised in our contemporary societies. In Europe, it is estimated that for each museum that existed in the 1950s, four exist today (Ambrose and Paine, 2006), while in the United States attendance of museums doubled from 200 million in 1965 to nearly 400 million in 1984 and 500 million some years later, rendering thus museum visiting as the one of the most popular family activities in America (Falk and Dierking, 1992). And though this trend cannot but be viewed positively, adverse consequences can also be observed. In Germany, for example, the number of museums increased by 30% in between 1991-1996 but the public's attendance only by 5% (Burton and Scott, 2007). Museums are thus competing not only with each other but also with other venues and attractions for a public that has less time available than ever before.

However, the most decisive change of the last decades is not the increase in terms of existing museum numbers but the increasing "opening up" of the museums and their collections to their public. In other words, museums passed from a state of "being about something" to "being about somebody" (Weil, 2007); and while they have been characterized at their first state as "elitist" (Schubert, 2000) or "static" storehouses, mainly focused on the acquisition, preservation and study of their collection that was subsequently presented as something objective and rational without further discussion or explanation (Hooper-Greenhill, 1994), today museums seem to understand that public exhibition and interpretation is at least equally if not more important than collection and research. Reflective of this tendency is that during the 1990s in Australia and the USA many museums devoted more resources to visitor and audience research than to any other activity (Griffin and Abraham, 2007).

At a time when we observe a developing emphasis on lifelong learning regarding both formal and informal learning environments, the museum setting -defined by the International Council of Museums (ICOM) as "a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment" (ICOM, 2007)- seems to represent an ideal, multisensory, informal learning environment, open to and able to satisfy a wide public, of different ages, abilities and backgrounds (Dierking, 2007).

The importance of this particular character of a museum visit is also strengthened by the common assumption that museums and other cultural heritage related institutions incorporate not simply objects, but the intellectual values, history and tradition of the society, thus emphasizing the continuity between the previous and the upcoming generations. This is also the reason for which the public sees in museums a leisure activity, closely connected with learning, and differentiated from other "short-term thrills" attractions (Hooper-Greenhill, 1994).

As the change in terms of focus and mission of museums is changing, museum visitors are valued more and more as active meaning makers with a right to a meaningful and informative experience when engaged in a museum visit (Berger, 2004, Doering, 2007, Falk and Dierking, 1992, Schubert, 2000). Museums therefore are now more than ever before experimenting with different strategies and different media not only in order to assist their visitors in getting the most out of a museum visit but also in order to create long lasting relationships with their public. Educational programs for families and schools, guided visits for individuals or handicapped people, audio guides, hands-on workshops and multimedia applications represent now some of the standard interpretation media visitors are provided with in many museums and cultural institutions.

Under this scope, the introduction of lightweight handheld multimedia guides as personalized assistants for interpretation purposes can be seen as one of the latest trends regarding museum educational and interpretation policies, providing a spectrum of functions that will be further examined in the next chapters (particularly in Chapter 2 and 4). On the other hand, examined under the scope of the MHCI community, museums, because of their public and educational character, seem to represent an ideal testbed for experimentations with mobile computing, mobile learning and entertainment applications.

1.3 THE RESEARCH SETTING

This study has been conducted in an industrial and business-driven Research and Development environment, France Telecom R&D (currently Orange Labs), in Cesson Sevigné, France. France Telecom is primarily a telecommunications provider, though lately a number of other services are also proposed to companies and the large public in several countries in Europe, Asia (Peking, Japan) and USA (San Francisco, Boston). The R&D division employs approximately 3000 engineers who deploy their research in the fields of signal processing and telecommunications, but also in other computer science disciplines, ranging from image, video and audio coding, to networks, information systems, multimedia, and interaction design.

The France Telecom R&D laboratory that hosted the internship, IRIS (Image, Rich Media, New Interactions and Hyperlanguages), has been particularly active in Virtual (VR) and Augmented Reality (AR) environments including intelligent, 3D avatars and agents. Some example applications is the 3D visualization of the city of Rennes for which a 3D interactive visualisation tool was developed allowing to access information on public services (location, opening hours, etc.), public transportation (location, timetable) or sport installations. Virtual Collaborative Environments is another axis of research and experimentations aiming to explore and investigate novel interface solutions. The work performed on intelligent avatars on the other hand, aims to develop a more user-friendly and entertaining access to distant communication services.

Augmented Reality (AR) has been lately representing another important sector of research for the IRIS lab. The Augmented Reality (AR) concept aims to enhance our real world perception, combining it with fictitious, computer generated objects. Some of the related topics of research are the development of computer vision algorithms enabling robust and accurate bindings between real and virtual worlds, the definition of new metaphors in order to control the interactions between the virtual world and the coexisting real world, and hardware developments for appropriate visualization systems (for instance see-through glasses). The possible market for AR applications can be industrial (maintenance, assembly), personal (gaming, support for disabled and elderly people, online shopping), mobile (geolocalized services, gaming), artistic, medical or educational. However, as AR is a relatively young and discipline, AR applications have been so far mostly addressed to a very marginal public related with specific disciplines (medical and military training, architecture, urban planning, industrial maintenance etc). Within this scope, the public and rich in connotations character of the museum environment renders museums very interesting as experimentation environments for mobile AR applications.

The PhD thesis research also benefited from a very close collaboration with the research team Médias Interactifs et Mobilité (Interactive Media and Mobility) of the CEDRIC laboratory in the Conservatoire National des Arts et Métiers, Paris, France. Some of the main research activities are related with the conception of multimodal, interactive 2D and 3D interfaces (visual and auditory) and the development of tools and environments for the authoring of multimedia applications. Particular emphasis is given on the techniques of conception and development of video games as well as on mobile multimedia applications and digital libraries. The laboratory maintains close relations with the Musée des Arts et Métiers and has been actively involved in the digitisation of the virtual library of the Conservatoire (cnum.cnam.fr), featuring more than 600 000 digitised pages, among which some very important 19th century journals, of particular interest for the scientific community of the History of Science.

1.4 RESEARCH QUESTIONS

In the previous sections the amalgamation of the PhD topic, as a result of both the author's motivations and objectives and the research motivations and activities of the settings in which this study was undertaken was examined. More in particular, and with a chronological order, the research questions that were formed are the following:

- What is the context of use of mobile multimedia museum guides and how do they differ or complement other already existing interpretation means? Which are the current challenges and barriers involved in the conception, implementation and integration of this interpretation medium in the museum environment?
- In which ways interaction while using a mobile multimedia museum guide differs from other cases of mobile human computer interaction?
- Can mobile AR technologies and the AR metaphor constitute an interesting alternative for interaction and navigation in a mobile multimedia museum guide application but also in the sensitive museum ecology? Can AR facilitate orientation in navigation in the museum space and the interactive application? Is mobile AR easy and intuitive to understand even by non experienced IT users? Are there any new emerging ideas regarding possible ways of interaction with mobile AR applications?

The research and methodological approach adopted for answering these questions is visited in the next section.

1.5 RESEARCH APPROACH AND METHODOLOGICAL CONSIDERATIONS

The nature of the treated topic implied from the very beginning an interdisciplinary approach. As a consequence the research and methodology employed associated resources from the domains of human computer interaction (HCI), augmented reality (AR), interaction design, museum and visitor studies and evaluation. The study also benefited by the ongoing progress and research in the field of cultural informatics, a concept broad enough to accommodate work carried out in diverse fields such as databases, digitization, computer animation, virtual and augmented reality and interaction design and evaluation, employed for the documentation and interpretation of cultural heritage and cultural heritage related applications.

In more practical terms the literature review was combined with hands-on experience in three projects (DANAE, Mobivisit and Museum of Fine Arts in Rennes projects), numerous on-site museum visits and multifaceted fieldwork undertaken in order to conceive, design, author and evaluate a mobile multimedia guide using mobile AR technologies and the AR metaphor as the predominant geolocalization, orientation and navigation component. Finally, the main AR prototype, built in order to explore the main research hypothesis through the integration of the AR metaphor in a mobile multimedia museum guide, was largely conceived and evaluated using participatory design practices which resulted in informative feedback that was taken under consideration in the next- financed by the French National Agency for Research (Agence National de Recherche) - phase of the mobile AR guide of the Museum of Fine Arts in Rennes.

1.6 COLLABORATION STATEMENT

The following entities and people deserve a specific mention, since a substantial part of the thesis would not have been possible without them. Following a chronological order:

- Christian Lecoq, research engineer, France Telecom R&D, for sharing important information regarding a more ancient mobile museum guide prototype developed by France Telecom R&D.
- The DANAE consortium and partners who contributed to the overall planning of the design and implementation of the Museon museum mobile museum guide application.
- Hub Kockelkorn, museum curator and head of the New Technologies department of Museon museum in Den Hague, Netherlands, who worked jointly with the author for the initial and already published version of the mobile museum guides evaluation taxonomy.

- Antigone Marangou, Professor of History and Archeology in the University of Rennes 2, Rennes, France, who discussed with lots of patience and perseverance the mobile guide functions list set-up by the author and provided relevant feedback.
- Pascal Houlier, research engineer, in France Telecom R&D, who implemented in C the 1st AR prototype, supervised and co-developed the implementation of the 2nd AR prototype and participated in the content authoring phase of both prototypes.
- Isabelle Marchal, research engineer, in France Telecom Research and Development (Orange Labs) who co-developed together with Pascal Houlier the 1st and 2nd AR prototype and participated in the content-authoring phase of both prototypes.
- Alban Jouvin who, during a 6-month internship in France Telecom R&D, developed, in C++, the 2nd AR prototype that was used as a base for the Museum of Fine Arts in Rennes prototype.
- Anne Bationo, ergonomist and research engineer in France Telecom R&D, who participated in the initial stages of the evaluation process carried out and made possible the remuneration of the candidates that participated in the experimentation.
- Laurence Imbernon, museum curator in the Museum of Fine Arts in Rennes, for accepting the commitment to write and validate the content scripts for the scenarios of the 2nd AR mobile museum guide prototype and for kindly allowing the author to take active part in this process.
- Odile Hays, Carole Marsac, and Anne - Sophie Guerrier, museum educators in the Museum of Fine Arts in Rennes, for creating and providing sequences of interactive content that was included in the 2nd AR prototype.

1.7 STRUCTURE OF THE THESIS

Including the present introductory chapter, the thesis is composed of 7 chapters and is divided in two parts. Part A, composed of chapters 1, 2 and 3 lays the theoretical foundations regarding the main research hypothesis. Part B, composed of chapters 4, 5, 6 and 7, explores and tests this research hypothesis, through the iterative design, implementation and evaluation of a mobile AR guide for a contemporary French state museum of Fine Arts.

Chapter 1 introduces the topic, the research problem, the motivations and the objectives of the work undertaken, the research questions as well as some methodological issues and briefly discusses the main contributions and outcomes of the research.

Chapter 2, "Mobile Multimedia Guides in the Museum Setting", presents the state of the art in mobile multimedia guides for the museum setting, a topic that provided the initial canvas for the main research hypothesis to be deployed. This chapter introduces a set of classification criteria regarding mobile multimedia museum guides (media employed, geolocalization capabilities, data storage, platform type, platform ownership, personalization, collaborative applications, edutainment activities) in order to better comprehend the context of use and the potential of the examined application type. Particular emphasis is given on the different strategies employed for resolving geolocalization and navigation issues, both in the museum space and the interactive application, while two mobile museum guide projects, in which the author participated, Mobivisit and DANAE, are presented in more detail. This chapter also highlights human, economical and technological challenges and barriers to overcome that have been so far preventing the generalization of use of mobile multimedia guides in the museum context.

Having provided a theoretical background regarding the modalities of use of mobile museum guides, Chapter 3, "Introducing Augmented Reality for Mobile Multimedia Museum Guides", looks deeper into the complex issue of interaction with mobile devices in the museum environment. After analyzing the ways in which a visitor's attention gets fuzzily allocated among the museum guide and the surrounding environment (the museum object and other co-visitors), the main research hypothesis is introduced: that the use of a still emerging technology, Augmented Reality (AR), and the corresponding metaphor it introduces, might have the potential to enrich and facilitate the interaction of a museum visitor with the museum environment and the interactive application. The chapter then introduces and defines AR, looks into principal components of mobile AR systems, examines prominent types of applications and potential current and future displays. A state of the art particular to the current uses of AR in the Cultural Heritage domain is then proposed as well as the potential but also the current limitations of the AR approach.

After exposing the main research hypothesis examined by this thesis, the second part of the dissertation examines in detail the modalities involved in the design, implementation, content creation, assessment and evaluation of a mobile AR museum guide created for and with the Museum of Fine Arts in Rennes, France.

Chapter 4, "Design and Implementation of the AR Guide", begins by elucidating the first necessary steps taken towards the creation of an AR enabled mobile museum guide, through the making-up of a comprehensive functions list. Each function is investigated separately, together with a short overview of the ways AR could be employed to alter the overall user experience. The first AR mobile museum guide prototype, designed, implemented and assessed in the lab and several international conferences is then presented, as it formed the basis for the accepted proposal addressed to the Museum of Fine Arts in Rennes. The rest of the chapter examines the different stakeholders' needs, the research setting (the museum) and the iterative design process employed. The content creation process both in terms of interactive edutainment content and scenarios and content authoring is also exposed as well as the reasons that led the museum professionals in picking-up as a target group young people, aged between 18 and 30 years old.

Chapter 5, Methodology for Evaluation and Data Collection", is dedicated to the main methodological issues that shaped the planning of the evaluation process. Two relative sections examine current practices regarding mobile multimedia museum guides, and identify trends, practices, challenges and deadlocks in the evaluation of mobile Augmented Reality applications. After proposing a taxonomy for the evaluation of mobile museum guides and investigating the reasons for which evaluation is still underutilized among the AR scientific community, the main research questions that shaped the methodology and the protocol finally employed for the experimentations are put forward. The 1st group of questions is related with the AR character of the proposed intervention. The 2nd group of questions is more generic to the usefulness, the enjoyability and the overall impact of the use of a mobile multimedia guide in the museum environment. The remaining of the chapter looks into the evaluation protocol proposed for the experimentations in the Museum of Fine Arts in Rennes, consisting of direct and indirect observations, semi-structured interviews, the use of a survey and two focus groups. 12 participants, aged between 18 and 22 years old, representing two distinct museum visitors groups, frequent and occasional museum visitors participated in these experimentations. The chapter closes presenting the task and experimental setup of the experimentations.

Chapter 6, "Data Analysis and Results", is dedicated not only to the results obtained but also to the ways through which the data coming from all employed evaluation methods was analyzed. Each evaluation session (participatory observations, semi structured interviews, questionnaire, focus groups) is presented separately, using recurring issues that aroused before, during or even after the experimentations. An attempt to combine in a meaningful and coherent way data from all phases of the experimentation, so as to more effectively answer the main research questions is also provided, trying –whenever it is possible- to draw the line between AR- and non AR-related aspects sought by the museum experimentations.

Chapter 7, "Conclusions and Future Work", resumes the main thesis contributions both regarding the use of mobile museum guides and the AR character of the examined intervention, which was found indeed appropriate as an alternative proposition for navigation and orientation both in the museum space and the interactive mobile museum application. A critical appraisal of the mobile AR approach is also proposed before passing on to future work directions within a short term and long term horizon.

1.8 RELATED PUBLICATIONS

The majority of the contributions presented in this dissertation have been previously published in international conferences and reports.

Chapter 2

1. M. Brelot, A. Cotarmanach, A. Damala, and H. Kockelkorn, "Nomadic computing in indoor cultural settings: Intelligent connectivity, context awareness and the mobile museum experience," *ICHIM 2005,* Paris, 2005 (available at http://www.archimuse.com/publishing/ichim05/Kockelkorn.pdf).

2. A. Damala, C. Le Coq, and S. Bouguet, "Mobivisit: Mobile computing in the museum setting: A field study in the Museum of Fine Arts, Lyon," *ICHIM 2005*, Paris, 2005

3. A. Damala, C. Bouville, Converging towards broadband, augmented and platform independent "intelligent" cultural heritage applications. *Digital Applications for Tangible Cultural Heritage: Report in the State of the Union. Policies, Practices and Developments in Europe, EPOCH Survey 2004/2005*, Budapest 2006, pp 89-93.

Chapter 3

4. A. Damala, Augmented Reality Based User Interfaces for Mobile Museum and Exhibition Guides, CAA (Computer Applications and Quantitative Methods in Archaeology) 2007, 2-6 April 2007, Berlin.

5. A. Damala, P. Houlier, I. Marchal, Crafting the Mobile Augmented Reality Museum Guide, *9th International Conference on Virtual Reality,* Laval, 18-20 April 2007, pp 303-306.

Chapter 4

6. A. Damala, Design Principles for Mobile Museum Guides using Visitor Studies and Museum Learning Theories, IADIS (International Association for Development of the Information Society), Mobile Learning 2007, Lisbon, Portugal 5-7 July 2007, pp 277-281, (available at http://www.iadis.net/dl/final_uploads/200706R049.pdf).

7. A. Damala, P. Houlier, I. Marchal, Merging Augmented Reality Based Features in Mobile Multimedia Museum Guides, Anticipating the Future of the Cultural Past, CIPA Conference

2007, 1-6 October 2007, Athens, Greece, pp 259-264. (http://cipa.icomos.org/fileadmin/papers/Athens2007/FP051.pdf)

Chapter 5

8. A. Damala and H. Kockelkorn, "Evaluation strategies for mobile museum guides: a theoretical framework," presented at *Third International Conference of Museology: Audiovisuals as Cultural Heritage and their Use in Museums,* Mytilene, Greece, 2006 (in press).

9. A. Damala, H. Kockelkorn, A taxonomy for the evaluation of mobile museum guides, *Proceedings of the 8th conference on Human-computer interaction with mobile devices and services,* Helsinki, Finland, 2006, pp 273-274.

Chapter 6

10. A. Damala, P. Cubaud, A. Bationo, P. Houlier, I. Marchal, Bridging the gap between the digital and the physical: design and evaluation of a mobile augmented reality guide for the museum visit. In *Proceedings of the 3rd International Conference on Digital Interactive Media in Entertainment and Arts* (Athens, Greece, September 10 - 12, 2008). DIMEA '08, vol. 349. ACM, New York, NY, 120-127

CHAPTER 2

MOBILE MULTIMEDIA GUIDES IN THE MUSEUM SETTING

2.1 INTRODUCTION

Why are mobile guides introduced in the museum setting? Which needs does this new interpretation medium seek to fulfill? In order to better comprehend the context of this intervention we first focus on the issue of interpretation in the museum environment. Having defined this way the potential residing in every mobile museum guide project, we introduce a set of criteria that can serve as a method for the classification of relevant projects but also as a mean for the description of functional requirements.

Two mobile museum guide projects in which the author participated, DANAE and MOBIVISIT are presented in more detail, using the proposed criteria, with particular emphasis on orientation and geolocalization issues. Finally, human, technological and economical barriers related with the design, the implementation and the adoption of mobile museum guides are also exposed.

2.2 A CROSSROAD BETWEEN TRADITION AND INNOVATION

In order to better understand where mobile multimedia guides stand in the museum environment we have to consider that they make part both of what is widely known as *museum interpretation media* as well as part of what is known as *multimedia and information technologies in the museum setting* (Figure 2.1). This remark is essential with regards to the conceptualization, the design and the evaluation of applications for museum handheld devices.

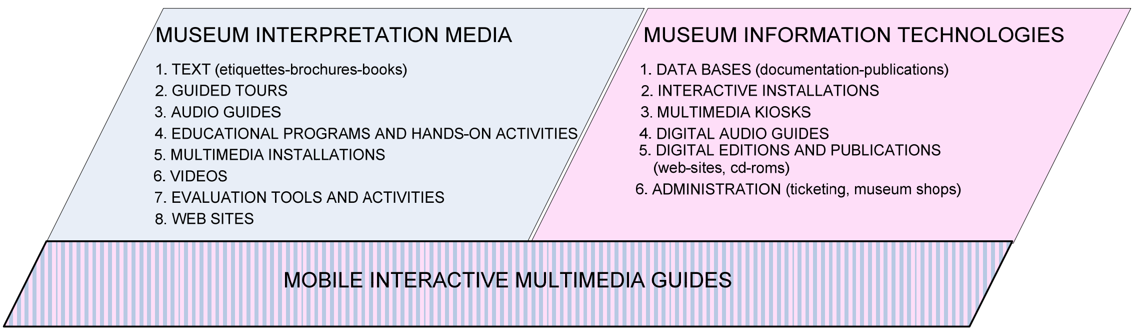


Figure 2.1: Mobile guides in the museum setting: a crossroad between tradition and innovation

Over the years, museums have slowly but steadily been transforming themselves from scientific environments addressed to a strict elite, to institutions embracing a plethora of activities in order to allow to a wide public, of different ages, backgrounds and abilities the apprehension of mankind's material and immaterial culture (Weil, 2007). In short, museums all over the world are becoming more and more aware of their potential and mission to act not only as scientific and research environments but also as educational and entertainment environments, serving thus with multiple ways human societies and their development (ICOM, 2007). We usually refer to the different means provided by the museum to the public for the apprehension and interpretation of museum exhibits, as *interpretation media* (Hooper-Greenhill, 2000). These may include text in a variety of forms (exhibits' etiquettes placed near the exhibits, printed brochures, paper guides), audio guides, guided visits, educational programs, multimedia installations and other multimedia products, like for example museum web-sites or other digital editions. In this context, mobile multimedia guides can be seen as one of the newest media introduced in the museum for the interpretation of both tangible and intangible cultural heritage.

But apart from constituting an interpretation medium, mobile museum guides make also part of *multimedia and information technologies in the museum setting.* This category includes documentation databases that complement, replace or co-exist with physical archives, museum web sites used for communication, documentation and interpretation purposes, interactive multimedia exhibits and installations, digital audio guides and information systems and multimedia used for publishing. In addition, information technologies in the museum are also used for administration purposes like for example ticketing or transactions taking place in the museum shop.

It is therefore not arbitrary to allege that this new medium stands in the cross-section of these two categories, allowing thus the coupling of the instances belonging to both classes. Multimedia-enabled mobile museum guides can hypothetically deliver all kind of interpretation material already used in the museum and also benefit and communicate with other multimedia and information systems used in the museum for various purposes. Combining elements of both categories, results in different functional requirements that this chapter will progressively explore. It is however obvious that mobile multimedia guides can provide an intelligent platform that can be used for a variety of purposes serving not only the need for communication between the museum and its visitors but also evaluation and administration purposes. The potential of this new medium will be explored in the remaining of this chapter.

2.3 CRITERIA OF CLASSIFICATION FOR MOBILE GUIDES IN THE MUSEUM SETTING

Introducing criteria of classification is not only a step towards establishing taxonomies, but also a very efficient way of presenting an overview of the possible functions mobile museum guides can integrate. The examination of mobile multimedia guides' projects using the proposed criteria, allows the identification of the main research questions each project seeks to explore. Finally, the systematization of the criteria leads also to a better comprehension of open issues to address and barriers to overcome.

2.3.1 1ST CRITERION: MEDIA USED

The first criterion upon which mobile guides can be classified is provided by the type of media they can deliver. This criterion will also allow us to historically approach the evolution of the examined medium.

2.3.1.1 Audio Guides

The most ancient predecessor of mobile multimedia guides is said to be the 1957 reel-to-reel tape audio guide produced for the house of Franklin Roosevelt, in Springwood, USA, with his wife, Eleanor, being the narrator (Leigh, 2007). A compact version of this first magnetic cassette player can be seen in Figure 2.2a. The introduction of Sony walkman in 1979 apart from revolutionizing music listening habits altered also the landscape in museums and other cultural heritage institutions. Walkmans were enthusiastically adopted by museums around the world, despite the fact that the audio commentaries were confined to limited duration, linear delivery and one single language per cassette and device. In museums of the size of Pergamon Museum in Berlin, it was not uncommon to pass in front of gigantic cupboards in which audio guides were classified by delivery language.

Without any doubts, the transition from the analogue to the digital, in 1994, dramatically changed the scenery in audio guidance systems (Proctor and Tellis, 2003). Visitors were now provided with the possibility to roam in the content in a way that had nothing to do with the linear, predefined navigation in the analogue audio guide's sequences. The storage capabilities of the new digital audio guides also allowed the creation of rich thematic tours and the delivery of audio content in several languages.

Figure 2.2.2a-2.2d: Generations of Audio Guides. From left to right: a compact reel-to-reel cassette player (A), sony's walkman (B) and two mp3-audio guides(C, D).

Today, commercial audio guidance systems propose mp3 systems that can store up to 550 hours of audio (Acoustiguide, last accessed November 2, 2008), in multiple languages, with easy switching from one language to another, while integrating sophisticated modules that give the possibility to collect and store visitors' data for later analysis. Some of these guides are also dotted with Infrared and RFID capabilities for triggering appropriate content, while accompanying software, assisting museum professionals in managing the audio content (add or delete audio files, or update the content) has also made its appearance.

Lately another approach for the delivery of audio commentaries is the creation of mp3 tours and podcasts that can be directly downloaded to visitors' self owned terminals (Samis and Pau, 2006) or cell phones (Nickerson, 2005). The content may be either released by the museum itself (e.g. Museum of Fine Arts in Rennes, San Francisco Museum of Modern Art, Metropolitan Museum of Art, National Gallery London etc) or other entities, as is the case with BBC's "Take One Museum" TV show (BBC, Last accessed November 2, 2008).

2.3.1.2 Multimedia Guides

The history of mobile multimedia guides is closely linked with this of mobile computing. Though the release of the 1st PDA, Apple's Newton, occurred only in 1993, the 1st mobile museum guide project, the iGo guide for the Minneapolis Institute of Art, dates back to 1994 (email communication, James Ockuly, September 3rd 2008). As suggested by their name, multimedia guides can combine all different types of media: text, audio, image and video and include other interactive features. Though mobile multimedia guides are still far from being the norm, Nancy Proctor lists 101 mobile museum guide projects released until 2005 (Proctor, 2005). This record is valuable, as many of these projects were discontinued and/or never published, conditions rendering extremely difficult the systematic review of some early projects. In this context, the two "electronic guidebook" forums organized by the Exploratorium, in San Francisco, in which many active in the domain professionals participated, constitute a precious source of ideas, experiences and guidelines (Exploratorium, 2001, Exploratorium, 2005). Equally interesting is the now discontinued action of the CIMI Handscape consortium (Spinazze, 2002), which from 2001 to 2004 sought to investigate use-cases of mobile multimedia guides in museums and art galleries. In Europe, the first known project is the 1997 European HIPS project that set the goal of creating a portable multimedia guide, both for indoor and outdoor use, as early as 1997 (Broadbent and Marti, 1997) while over the Atlantic, the Exploratorium, a popular science museum in San Francisco, launched one of the first handheld guides in 1998 (Hsi, 2002). Today, far more services and possibilities seem possible than ever before. In addition, to the knowledge of the author, a german product, Xpedeo (Xpedeo, last accessed October 31st, 2008), also proposes software allowing museum professionals to create the guide's content alone.

It is important to notice that in the international bibliography, there exist several ways of reference to this kind of devices and projects. During the early days, these devices were referred to as museum handheld devices (Cabrera et al., 2005, Ciavarella and Paternò, 2004, Exploratorium, 2005, Hart, October 2005, Kwak, 2004, Manning and Glenda, 2004, Olson, 2007, Pham, 2004, Proctor, 2004, Schmalstieg and Wagner, 2005, Tellis, 2004). "Mobile museum guides" (Albertini et al., 2005, Butz, 2002, Damala and Kockelkorn, 2006a, Damala and Kockelkorn, 2006b, Damala, 2007a, Damala, 2007b, Oppermann and Sprecht, 1998, Santoro et al., 2007) and "nomadic devices" (Brelot et al., 2005, Damala et al., 2005, Hsi, 2004, Vlahakis et al., 2005) are other variations often enough used in the relevant literature.

2.3.1.3 Visio Guides

Despite the fact that today's mobile multimedia platforms can deliver all kind of media types, sometimes, a conscious choice is taken so that museum handheld guides provide only audio content together with minimal visual information. In this sense, chronologically, visio guides are not predecessors of mobile multimedia guides, but rather successors. Visio guides have been used in the "Brush in History" exhibition in the Smithsonian Institute, in New York (Olson, 2004) as well as in the "Rembrandt's Late Religious Portraits" exhibition that took place in the J.P. Getty Institute (Hart, October 2005). The visitors activated thumbnails of the images to access the relevant audio content.

If visio guides can be considered as a sub-category of multimedia guides, the same does not hold true for a new generation of audio guides, like the guide created by Acoustiguide for the British Museum on the occasion of the Hadrian: "Empire and Conflict" exhibition in July 2008 (on site visit and testing of the guide by the author on Sunday 27th of July). The wand-form audio guide proposed was dotted with a small screen, used to show the image of the commented exhibit not for navigation purposes but as a constant visual reminder of the commented work.

2.3.1.4 Multimedia, Augmented Reality-Enabled Guides

Finally, a last but still emerging category of guides could be linked with the use of Augmented Reality technologies, as the one that will be exposed in this PhD thesis. These guides are equipped with a camera that captures the surrounding environment in real time and uses it as a canvas for the delivery of multimedia information by superimposing on the video of the real environment virtual overlays with which the user can interact. The main motivations regarding this approach, including design, implementation and evaluation issues are systematically explored from Chapter 3 onwards.

Experiments with mobile Augmented Reality systems have taken place in the archaeological site in Ancient Olympia, Greece (Vlahakis et al., 2004, Vlahakis et al., 2003) and in the participating museums of the "Ecsite" project (Anastopoulou and Sotiriou, 2005). Experimentations in a museum environment have also been conducted by the German team of the Weimar University, but using cell phones as delivery platforms (Bruns et al., 2005). Mobile, multimedia, Augmented Reality-enabled guides are very promising, as in the near future, technological innovations could imply great changes not only regarding visual displays but also human computer interaction with mobile devices and services.

2.3.2 2ND CRITERION: GEOLOCALIZATION

2.3.2.1 Introduction

Geolocalization or localization is an issue of great importance concerning a museum visit. This is because, regardless of the nature of the interpretation medium employed, a museum visitor needs to know how to make the link between the interpretation material used and the object to which it refers, to correlate the signifier with the signified.

Nancy Proctor, in her article "Off-Base or On Target? Pros and Cons of Wireless and Location-Aware Applications in the Museum", not only discusses this issue, but also provides a valuable list of 101 mobile museum guides' systems, in their majority never published, grouped by geolocalization or triggering technology (Proctor, 2005). Here we will follow her classification also introducing a somewhat different approach, by proposing that more generally, there are three possible ways the signifier can be correlated with the signified. The link can be in the museum physical environment, on or within the interpretation medium, or in both environments. The third solution is the most widely spread.

Figure 2.3a-2.3g: A. Tate Modern, London. B. Eternal Egypt project. C. Mackintosh Center, Glasgow. D. Natural History Museum, Tokyo. E. Natural History Museum, London. F. Cité des Sciences et de l'Industrie, Paris. G. Vincent Van Gogh Museum, Amsterdam.

Whatever the solution, the task in many cases remains difficult to achieve. This is why mobile guides in the museum setting do not only promise to deliver rich multimedia and multisensory content but also to assist museum visitors in accessing the right information on the right spot (Oppermann and Sprecht 2000). Technically this may be achieved using a variety of techniques and underlying technologies, which the remaining of this section, sets to explore. Each solution presents advantages and disadvantages which should be examined carefully before opting for one or the other solution.

However, geolocalization capabilities can do much more than just help visitors locate themselves in the museum premises. For example, they can reveal to the museum personnel the exact position of each visitor, allowing thus a control of visitors flow. Versailles in France was very interested in such a possibility that would allow a better management and control of visitors flow during periods of great visitor affluence (Interview of the author with Christian LeCoq, France Telecom RD, November 8th, 2004). Geolocalization could also allow visitors to know and visualize where other co-visitors are found in the museum. For example, Danae project for Museon museum in the Netherlands included such a function, in order to assist co-registered visitors, e.g. the members of a family, locate the position of other members of the group (Brelot et al., 2005). A slightly different in nature example is provided by Legoland in Denmark where a geolocalization system based on RFID tags is used in order to detect the location of children that get lost in the park (Collins, 2004). At the same time, geolocalization can also be a prerequisite for edutainment, computer-supported collaborative applications. The rest of this section explores the different geolocalization methods employed in mobile museum guide projects.

2.3.2.2 Declarative/ Explicit Geolocalization (using alphanumeric or visual clues)

Geolocalization or localization during a museum visit is not an issue proper only to the use of mobile multimedia guides. The use of any kind of interpretation media is strongly linked with the notion of the domain space. However, the closest pre-existing practices in the museum premises can be detected in the museum-object identification scheme utilized in audio guides; audio guides have been using museum etiquettes next to exhibits to indicate to the visitor that a work is commented and provide him with the number to access this resource (Figure 2.4a). This system is also often used when delivering mobile multimedia guides, sometimes in conjunction or as an alternative to other geolocalization means (Figure 2.4a).

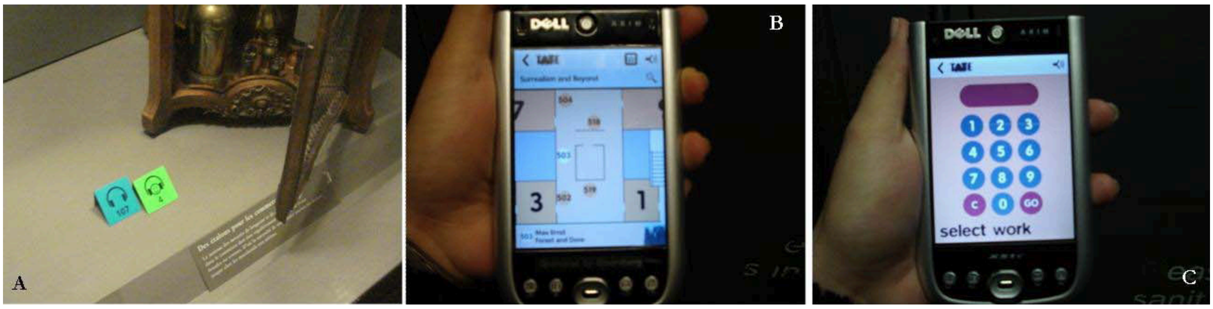


Figure 2.4a-2.4c: Examples of declarative (explicit) geolocalization. Conservatoire National des Arts et Métiers(A), Paris and Tate Modern, London (B, C).

Another way of helping the visitor during the visit is to use the above mentioned method together with a photo or thumbnail of the commented exhibit that presumably helps the user in identifying the commented exhibits (Figure 4b). This was the approach used in the children's mobile multimedia guide provided by Sycomore for the Gauguin exhibition in Paris' Galleries du Grand Palais (Calabre, 2004). It has been also used in the Mobivisit project described in section 2.3, by the recent multimedia guide of the Louvre (Louvre, 2008) and by the British museum in the 2008 temporary "Hadrian: Empire and Conflict" exhibition (BritishMuseum, last accessed October 31st, 2008). The guide, created by Acoustiguide, was essentially an audio guide and had the form of a normal telephone headset dotted with a screen that constantly displayed the image of the commented exhibit. A disadvantage of this solution is that museum galleries are often large and do not favour the immediate visual identification of the commented work. Another issue is that the unrealistic rendering of the colours of an original work may have the same effect (Damala, 2005).

A 3rd approach that can be used in conjunction with the above, is to provide the visitor with a digital plan of the exhibition on which he/she is asked to locate himself, locate where the commented work is, and then figure out his trail towards this spot (Figure 4b). Though this solution is more and more available in mobile multimedia guides, it seems at times that it is overestimated. Evaluation (Damala et al., 2005) and extended observation sessions of the author in several museums have shown that this approach is not easy to use. It comes therefore as a surprise to see that it is employed under all circumstances, as is the case in Tate Modern Gallery, proposing this solution not only in the adults' tour but also in the tour destined for children (on site visit, July 27th 2008). DANAE project, described more in detail in section 2.4, also used a plan of the gallery to assist visitors in the localization of the commented exhibits. Finally a last way of declarative aid in geolocalization was used in Mobivisit project where visitors were asked to fill in a three-field form that then returned as a result their position on a digital map (Damala et al., 2005).

2.3.2.3 Bluetooth Geolocalization

Bluetooth is the name of a standard developed by many electronic manufacturers including Nokia, Ericsson, Siemens, Motorola and Toshiba. It took its name after Harald Bluetooth, king of Denmark in the late 900s who managed to unite Denmark and part of Norway into a single kingdom and introduced Christianity into Denmark after managing to negotiate with different, opposite parties. It is precisely for this reason that Bluetooth logo features the runic characters for H and B.

Bluetooth is a radiofrequency standard using a frequency of 2.45 GHz which has been reserved by international agreement. Bluetooth devices avoid interfering with each other by using very week signals in conjunction with a technique called spread-spectrum frequency hopping. This means that the working frequency changes randomly 1600 times per second, thus minimising the possibility of a same frequency used by different paired devices. Bluetooth is used by a variety of devices ranging from mobile phones to garage doors, and baby monitors.

One of the advantages of Bluetooth is that it does not require line-of-sight between communicating devices. A maximum of eight devices can be connected simultaneously in a radius of 10 meters creating a Personal Area Network or Piconet. Furthermore the Bluetooth protocol demands much less energy that the more power-demanding Wi-Fi protocol.

As Bluetooth was developed as a low-powered, low-bandwidth (1Mbit/second) protocol, it was finally used more as a communication protocol for connecting mobile phones between them or with printers or computers. In museums it can be used as a triggering technology of short-range, that cannot really deliver rich multimedia content. This is why Bluetooth has only been used once in a museum environment, in the Tussauds' museum in London (Proctor, 2005) in form of Bluetooth triggers that activated PDA, locally-stored content. Bluetooth triggering functions the same way as infrared triggering described in the next session. Using Bluetooth for triggering could be an interesting alternative for visually impaired visitors as it does not require line-of-sight.

2.3.2.4 RFID

RFID (Radio Frequency Identification) refers to technologies using radio waves to automatically identify objects. In today's everyday life the term is most used for systems using an RFID receiver in conjunction with small RFID chips attached to an object. In the museum environment, the chip can be attached to objects easy to carry, such us a watch, a bracelet, or a card (Figure 2.5b). This item is then sending its ID to the network by means of the RFID transceiver mounted on the exhibit. The transceiver records and sends the visitor identification number to the network and the database system while also tracking the actual path of the visitor in the exhibition. However in the case of Carrara museum in Italy, the use of passive RFID tags forced visitors to approach very closely to the artworks and were subsequently replaced with active RFID tags (Santoro et al., 2007).

RFID does not require line-of-sight. Exploratorium in San Francisco has experimented with RFID technologies as several studies showed that users preferred to have their hands free while wandering in the museum. Visitors could bookmark information and take photos of them in front of exhibits that were available on line in a personal web page (Hsi, 2005, Hsi et al., 2004).

A slightly different approach has been adapted by a Gallery in New Hampshire, USA. RFID chips were placed next to the artworks. Visitors can borrow one of the three PDAs together with an RFID - Bluetooth pen. They trigger that way information about the artwork on display, then bluetoothed to the PDA that displays that way information on the selected work (Proctor, 2005). The RFID technology was also tested in the Conservatoire National des Arts et Metiers museum in Paris, France (Merdassi et al., 2007).

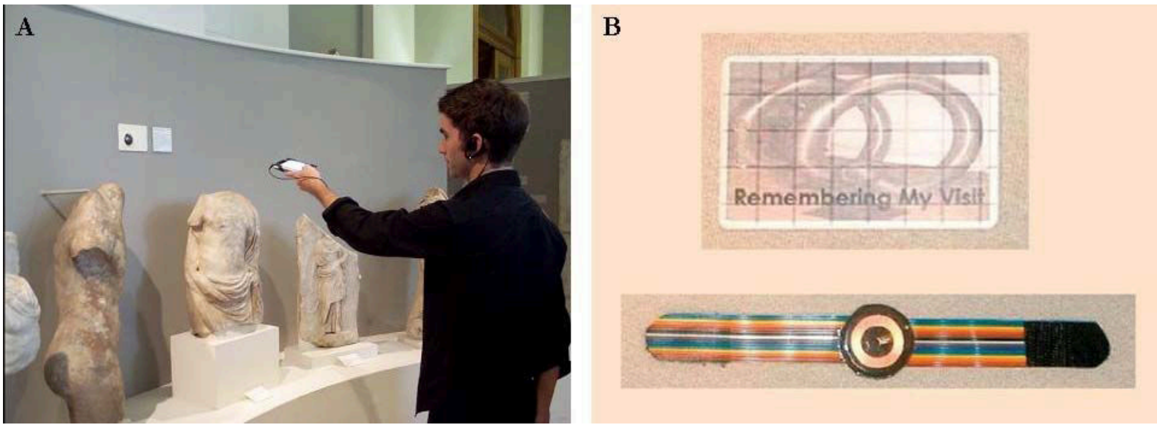


Figure 2.5a-2.5b: Small infrared tags installed in object labels, Fitzwilliam Museum, Cambridge (A), UK (Proctor, 2005). RFID card and watch tried out at the Exploratorium (B) (Fleck et al., 2002)

2.3.2.5 Infrared Geolocalization

The infrared protocol of communication supports data rates almost as high as a WLAN and does not interfere with other devices. On the disadvantages is that it is a "line-of-sight" technology that requires a "clear" path between the trigger, placed above a door or in a room, and the handhelds' infrared receiver. Infrared triggering (tagging) can be used both for delivery of locally stored content as well as for delivery through a wireless network and can be passive or active. Active triggers cause the activation of the appropriate content while passive triggers need to be activated by visitors.

There exist as well small infrared "tags" that are designed so as to be placed discreetly next to the exhibits or even built in exhibit labels (Proctor, 2005). However it might be difficult for visitors to approach if there are many persons in the same room. Infrared tags come with special software that allows updating and management of the content associated with each tag. The system can also alert the administrator if the batteries of the tag are running low.

Figure 2.6a-2.6c: Infrared audio guide, Museum of Musical Instruments (MIM), Brussels

Museums that have been experimenting with the infrared technology is the Marble Museum in Carrara (Ciavarella and Paternò, 2004), la Cite des Sciences et de l'Industrie in Paris (Proctor, 2005) and the National Museum of Cinema in Turin, Italy (Monaci and Cigliano, 2003). Infrared technology was also used in Seoul's Leeum museum where walking up to a work triggers an Infrared sensor prompting the PDA to introduce the exhibit with text and recorded voice (Choi, 2005). The same principle applies also to an infrared audio guide proposed by the Museum of Musical Instruments in Brussels, Belgium (on site visit, August 3rd 2008). The particularity of the guide is that it consists only of an infrared headset equipped with an antenna. Special spots are designated in form of circle in front of the musical instruments showcases. The visitor has to step on them in order to listen via the headset to the music produced by the instruments (Figure 2.6a-2.6c).

2.3.2.6 Wi-Fi Geolocalization

Wi-Fi (Wireless Fidelity) technology allows devices to connect to the Internet/Intranet in a range of 100 meters without demanding line-of-sight. This technology is based on IEEE 802.11 specifications. Wi-Fi can connect potentially unlimited visitors with a theoretical data transfer of 54Mbit/second. The high bandwidth delivery to Wi-Fi enabled devices provided the possibility of remote content storage and automatic content update from a single, central server.

In terms of function, four elements are necessary to a wireless network: a central server where the positioning software is installed and where the location calculations are made, several access points that relay radio signals between the visitors and the server, Ethernet cables and switches, to connect the access points to the server, and finally the Wi-Fi enabled terminals (Proctor, 2005).

When visitors move around the museum, the handheld devices send signals to the access points. With signals of at least 3 access points (triangulation) and the parallel use of a radio map, the positioning software can calculate each visitor's location with a granularity of 1 to 3 meters, depending on the circumstances (from walls and iron objects that can interfere with the signal to humidity and number of visitors in the same room). For further "tuning", Wi-Fi technology can be combined with infrared, radio or Bluetooth triggers (Proctor, 2005).

Among the drawbacks of Wi-Fi we find the inaccuracy in location readings and the latency of content delivery. Though latency and accuracy can be improved by augmenting the number of access points, most museums prefer local storage of the content, even when they are equipped with wireless networks, as visitors can scarcely tolerate delays of more than a few seconds Proctor, 2005). Other disadvantages include the high cost involved in the deployment and maintenance of a wireless network and the extra effort needed to discreetly install the necessary infrastructure in the museum premises in a way that will not perturb the design and aesthetics of the exhibition.

Regarding the visitor terminals, another disadvantage is the high power consumption that makes battery life and heat a concern. Some of the museums that have experimented with Wi-Fi technologies are the Tate Modern, in London (Proctor, 2005), the Singapore Science Center (IDA, June 22, 2005), the Museo e Certosa di San Martino and the Institute and Museum of the History of Science in Florence (Galasso et al., 2004).

2.3.3 3RD CRITERION: CONTENT AND MEDIA STORAGE

The proliferation of wireless networks and delivery protocols and the geolocalization capabilities of mobile devices gave the possibility for the creation of new services relying on the transfer of remotely stored content. In the museum context we can now draw the line between museum guides that have all content stored locally, and guides that can retrieve content from a remote server.

This 2nd possibility opens up a new spectrum in functions and interactivity possibilities as content can dynamically be generated as a response to visitors' input. At the same time as the delivery of rich multimedia content demands lots of storage space, wireless delivery can potentially provide limitless content in real time. Collaborative activities are very much depending on the interconnection and exchange of information between different application modules. Polling, voting or leaving spatial messages to encourage public dialogue regarding exhibits could also be favoured by the use of wireless technologies. Finally, administrative tasks, visitors-flow management and automatic update of content can also be benefited by wireless content delivery.

2.3.4 4TH CRITERION: PERSONALIZATION

Personalization is a key issue regarding the design and implementation of mobile museum guides (Walker, 2007, Wang et al. 2007). For museum professionals, this is also one well known issue, as the educational and recreational character of the museum visit imposes different approaches in the proposed activities (Hooper-Greenhill, 1994, Jensen, 2004). At the same time, in the field of HCI, personalization is clearly recognised as an issue of particular interest. The same holds true for mobile human computer interaction (MHCI), where personalization is lately not only an issue regarding provided services, but also devices (Cheverst and Schmidt-Belz, 2005). Historically, for many, personalization remains a notion closely linked with the Internet. However the origins can be traced back to the first interactive role-playing games, where players chose a personality whose power and characteristics were developed by gaining in experience (Gee, 2003).

Customization and personalization are two terms that are often loosely employed. In reality a distinction is possible to be made between these two terms: Customization or adaptability occurs when the user creates a profile manually, removing or adding elements and thus configuring the interface, while personalization or adaptation is used when referring to a system that automatically modifies its characteristics according to the user needs (Filippini-Fantoni, 2003), either explicitly, from information provided by the user, or implicitly, by monitoring the application context (Brelot et al., 2005) or the performed actions (Bowen and Filippini-Fantoni, 2004). For the needs of this study however, we shall consider the two terms as equal.

Generally speaking, personalization is supposed to promote the filtering and adaptation of information to the user, facilitate navigation and therefore increase the speed of access to the application content. Parameters that can be taken under consideration are age, interests, level of education, previous knowledge etc.

Through the literature review carried out, both regarding the use of mobile guides in the museum as well as regarding current museum practices, nine criteria and services upon which personalization acquires its full meaning were identified. All criteria can be either applied alone or in combination between them. More specifically, personalization may be provided according to:

1. Age groups: The content of a mobile multimedia guide can be conceived and implemented in such a way, so as to provide different commentaries and activities according to the age group of museum visitors. This possibility has been used in many mobile museum guides projects, such as the Sycomore guide for the Gauguin exhibition in Paris in the Grand Palais (Calabre, 2004) or the Tate Modern multimedia guide that offers an adults and a children/family tour (on site visit, July 27th 2008). Tours especially created for school classes have also been implemented and reported to be successful (Cabrera et al., 2005).

2. Available languages: Another issue that could be addressed through personalization is that of language, as already demonstrated by the mp3 audio guides that are available in a plethora of museums around the world and have replaced the older cassette audio guides (Proctor and Tellis, 2003). One of the latest examples is the mobile multimedia guide designed and implemented for the Louvre, launched on February 2008, where the content is available in seven spoken languages and the French sign language (Louvre, 2008).

3. Visiting trails/bookmarking: In "That's Canada exhibition" in "La Cite des Sciences et de l'Industrie", museum visitors were provided with a PDA equipped with an infrared receptor. Each

time a visitor approached a zone of interest he/she could point his PDA to the tag to trigger the appropriate content. One of the activities consisted of visitors posing for a photograph in front of different exhibition-inspired fonts. The path followed by the visitor as well as the photograph taken were afterwards available in a personal web page, which could be accessed by means of a code distributed to visitors after the restitution of the PDA (Topalian, 2005). Roland Topalian reports that, for this particular exhibition, 56.500 cyberlogs were accessed, for 47.726 tracked visits. Bookmarking using a combination of RFID and Wi-Fi was also experimented in the Exploratorium in San Francisco (Hsi, 2005, Hsi et al., 2004). The Getty museum also planned to add a quintessence of personalization in its PDA guide, planned for launch in May 2004 (Bowen and Filippini-Fantoni, 2004). The guide would provide audio descriptions, images, text and interactive maps and would give visitors the possibility to bookmark up to 50 objects, accessible after the visit either on a personal web page or directly to the visitors' e-mail inbox. Another technique used for bookmarking consists of using barcodes distributed to visitors prior to the visit and activated by them each time they want to leave a "trail" that can be later consulted on a personal web page. This method is currently employed in the Museon museum, in Hague, the Netherlands.

4. Thematic visits: Another feature easy to implement in order to accommodate visitors different interests and needs, is the setting up of thematic visits. Taking again as an example the Louvre (Louvre, 2008), which is one of the first large museums in the world to offer a mobile multimedia guide, the 1st version of the guide released in February 2008 proposed nine thematic visits while in the 2nd version foreseen to be released in 2009, six additional thematic tours would be added (Louvre, 2008). Thematic tours were also proposed in the Mobivisit guide of the museum of Fine Arts in Lyon (Damala et al., 2005). In this category one should also add tours more or less detailed according to visitors particular interests and expertise. Other personalization issues that could be addressed have to do with the level of expertise of the visitors, their age, their particular interest in selected topics or available time. In the future, the use of metadata (CIDOC, 2006) could facilitate the automatic generation of thematic tours based on criteria such as different periods, materials etc. This type of personalized merchandise could be easily translated in a separate mobile museum guide module.

5. Personalized merchandise: Museums are non-profit institutions based mainly on tight state funding, private donations and revenues from admissions. In this context, museum shops can contribute to a greater or lesser degree in raising funds (Kotler and Kotler, 1998). Based on bookmarking of visitors' favorite exhibits, personalized merchandise could be proposed to

visitors, shortly before the end of the visit. The guide of the Senckenberg paleontological museum provides such an example. Visitors were provided with the possibility to take their own photos that were then forwarded to their email while collaboration with a telecommunications company enabled visitors to order personalized souvenirs with their favourite dinosaurs on them (Sauer et al., 2004, Sauer and Goebel, 2003). Another very recent example comes from the United Kingdom. Visitors of the National Gallery in London can enter the museum shop, consult a multimedia kiosk, then order and buy in real time a poster of their favourite painting in a size ranging from A4 (210 x 297 mm) to A0 (841 x 1189 mm) for a price ranging from 10£ to 75 £ (on-site visit, July 26th 2008).

6. Visitors' special abilities: There exists no better example to illustrate the advantages of personalization than this concerning visitors with special abilities. A guide for deaf or hearing impaired visitors was tested in Great Blacks in Wax Museum, in Baltimore, Maryland, and was then officially launched in Tate Modern, London, in October 2003 where it is still (July 2008) available (Proctor, 2004). This example has been followed by the Louvre recently (though of course it is not a coincidence that the same company undertook the creation of both guides). The plethora of geolocalization capabilities have also allowed the design and development of guides also destined to visually impaired visitors, as demonstrated in (Bellotti et al., 2003) and (Ghiani et al., 2008) based on RFID localisation, specifically developed to guide and help in orientation visually impaired people and inform them that they can touch an exposed exhibit.

7. These two examples could also inspire interface design and personalization for aged people facing problems with their vision (Proctor, 2004). An option that would let the user define the size and colour of the font could be very easy to implement. Yet, to our knowledge, no museum handheld guide has ever considered this option.

8. Visitor groups or communities: Another criterion is strongly linked with the social character of the museum visit. Though still not very common, there have been examples of mobile museum guides conceived also to be used by more than one visitor. This aspect is further examined in sections 2.4.5 and 2.5.7 where "social context" and "edutainment" aspects are examined.

9. Delivery platforms: As further examined in section 2.3, where the Mobivisit project is presented, in the future, visitors might use their self-owned terminals in order to download and

use multimedia interactive interpretation material. When this happens, the presentation of the content should be automatically adapted to the capabilities of the visitor owned terminal that will host the application. In this context, the DANAE project, examined in section 2.4, set as a goal to explore the requirements and the possible impact of providing visitors with such a possibility.

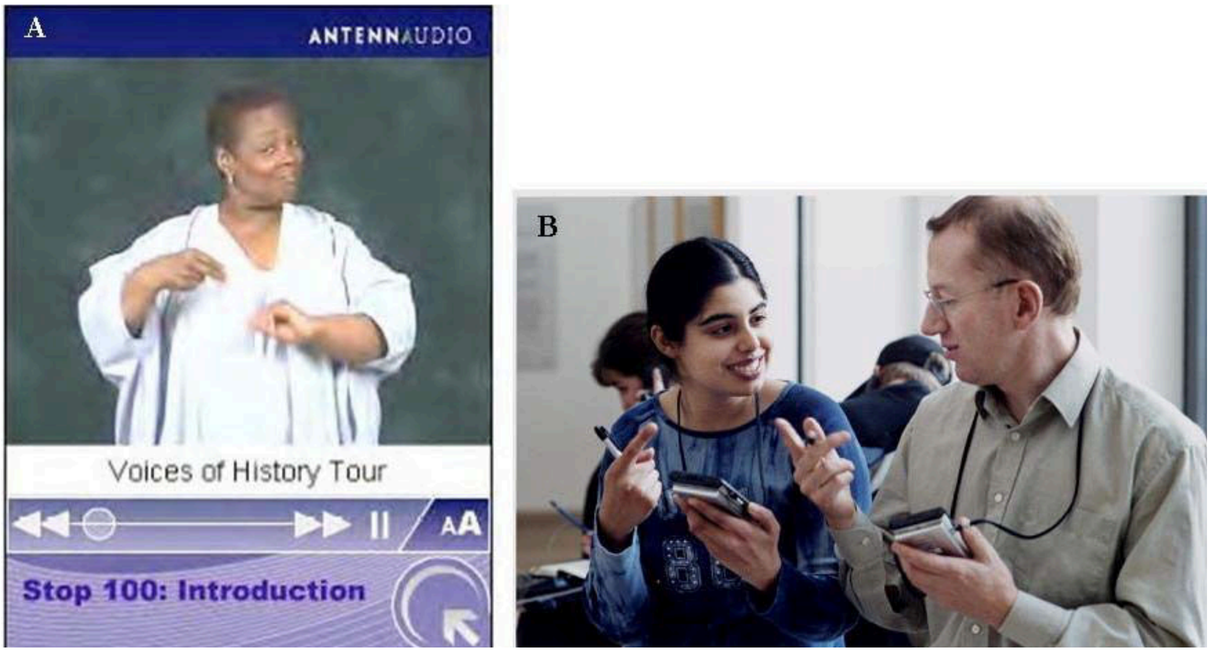


Figure 2. 7a-2.7b: The Great Black Wax museum deaf or hard-of-hearing guide (A) and two deaf visitors using the Tate Modern Multimedia Tour (B), (Proctor, 2004)

2.3.5 5TH CRITERION: SOCIAL CONTEXT

Undeniably museum visits are often also social in nature (Pujol and Economou, 2006).Studies have shown that especially among non frequent visitors, sharing the visiting experience is sometimes more important than the educational aspect of the museum visit itself (Hood, 1983). At the same time, an increasing number of museums attempts to involve museum visitors in a public dialogue around exhibits, proposing to the visitors polling and voting using multimedia kiosks, as for example is the case in Berlin's Jewish Museum (on-site visit, April 2007) and Museon museum in the Netherlands (on-site visit, February 2006). Taking under account the unanticipated success of SMS messaging, especially among young people, for communicating and keeping in touch (Grinter and Palen, 2002), the integration of communication services in mobile museum guides might in the future develop much faster than it has up till today (Arvanitis, 2005).

Concerning mobile museum guides, a conceptual schema was provided in the study of Woodruff et al. (Woodruff et al., 2001), supporting that the visitor interacts with three entities when using a mobile multimedia guide in the museum environment: the information source (e.g. the guidebook), other companions and the location itself. It seems however that for non-frequent visitors the need to share the experience with other companions is sometimes a higher priority. The same team also experimented with a prototype that allowed visitors to hear the audio sequences their companion was hearing when not engaged in an audio presentation (Woodruff et al., 2002). The PEACH project (Stock and Zangarano, 2007) also set out as a goal to explore this possibility and created a module that allowed a small group of visitors consisting of three to four persons to communicate using predefined or personal messages or "place" on exhibits "post-it" comments that they wanted their companions to see.

Alternative combinations regarding the way museum visitors communicate include the study conducted for "The Museum Detective Game", which set as a goal to explore the paired discovery of an art object in a museum, as in contrast with the much more common task of individual discovery of several objects. The evaluation that followed (16 pairs of pupils) proved that the children managed to use the guides cooperatively and that they retained an increased amount of factual data, that was however comparable with more traditional "hands-on" activities proposed by the museum (Thom-Santelli et al., 2006). A collaborative visit for pupils visiting in pairs but this time equipped each with one PDA was also planned for the Dionysios Solomos Museum in Zakynthos, Greece (Cabrera et al., 2005). Another approach was proposed by Brown et al. (Brown et al., 2003, Galani, 2005); a mixed reality system allowed the mutual discovery of the Mackintosh house in England where three, different in terms of location, visitors collaborated during a museum visit.

As communication using mobile devices in situations of mobility becomes an increasingly crucial field of study in mobile human computer interaction, several projects have also been launched for an outdoor use. For example Arvanitis examined the way students used their camera-equipped mobile phones to communicate information regarding open air monuments in the city of Thessaloniki, in Greece (Arvanitis, 2005).

2.3.6 6TH CRITERION: CONTINUITY OF USAGE

The 6th criterion introduced is the continuity of usage. Continuity of usage might have two declinations. In the 1st case, the mobile museum guide might have an outdoor counterpart, for example, an outdoor guide (Wood and Donovan, 2004) might be combined with an indoor museum guide. Concerning Cultural Heritage, this approach presents a great interest in the case of open-air excavated archaeological sites that house archaeological museums where the findings of the excavations are presented (Luyten and Coninx, 2004). A system in this case might help the visitor to visualize the links between everyday objects discovered in archeological digs and the exact location in which they were found, highlighting affinities and correlations otherwise difficult to perceive. However, to the author's knowledge, with the exception of an indoor Augmented Reality system tested for archaeological training purposes, such a system does not yet exist. In the few examples that exist in the bibliography, the continuity of usage is perceived as a combination of use of an outdoor tourist guide with an indoor museum guide as is the case with the "Eternal Egypt" (Tolva and Martin, 2004) project and Mobivisit (Damala et al., 2005), presented in section 2.4.

The 2nd declination is more museum-specific. The idea behind it is that more and more often, museum visitors plan in advance their museum visit, for example by consultation of the museum web site. In addition sometimes visitors extend the benefits of the museum visit, by looking up relative information, before the visit (Haaparanta & Ketamo, 2005) or after the visit has ended (Bowen and Filippini-Fantoni, 2004, Wessel et al., 2007, Kuflik et al., 2007)). Therefore, the idea of deploying a system that could accompany the visitor in all of the proposed pre- and post-visit activities, strengthening also the bonds of the museum with its public, can not but be of great interest and importance for museum professionals. Though few projects have so far examined this possibility, some first findings presented are very encouraging. For example, Topalian mentions that the Visit+ system that tracks museum visits and proposes to visitors personalized web pages for later consultation, had until 2005 generated a total of 104,000 Web sites and about 70,000 hits of coming back visitors (Topalian, 2005).

This notion of continuity has been examined by one of the earliest related projects, the HIPS (hippie) project, in 1999. The team proposed in the form of a scenario a system that would allow the visitor to access web pages before the visit, browse exhibits and setup a tour. During the visit visitors could access the artworks catalogue and look for the exhibits, while once at home they could have access to a fully personalized information space with objects seen in the museum where they could search for additional information (Oppermann et al., 1999). Linking the visit and the post-visit phase was also examined in the case of the Electronic Guidebook, created for the Exploratorium, in San Francisco (Fleck et al., 2002). In England, the science center "At-Bristol" invites visitors to email pictures and web links to themselves for consultation after the visit (Spinazze, 2002). A variation is provided by the PEACH project, where visitors following the visit, are provided with personalized recommendations of other cultural sites they might want to explore (Callaway et al., 2005).

An examination of all related projects shows that the majority of existing applications are developed either for indoor (Galasso et al., 2004, Exploratorium, 2005, Proctor and Burton,

2003) or outdoor applications separately (Borntrager et al., 2003), and that only in a few cases, a museum multimedia guide has been developed, to include an outdoor counterpart as well (Hall et al., 2001).

2.3.7 7TH CRITERION: EDUTAINMENT

About one third of museum and gallery audiences are made up by children accompanied by their families (Hooper-Greenhill, 1994). As interactivity and action is vital for children, a perception that the visit will be fun is crucial (Mazzone et al., 2004). Therefore educational games for museum handheld devices constitute an alternative to PDA escorted guided visits, especially attractive for children. But even considering adults, games and other edutainment activities can favour interaction and learning by triggering curiosity and engagement physically, mentally and emotionally and can also enhance the social character of the museum visit (Falk and Dierking, 1992).

Games and other play-like approaches are also fundamental for learning. As museum learning involves most of the time specific objects, games can introduce several non conventional ways for observing, contemplating and interacting with them while encouraging individuals to construct their own meaning based on other already acquired personal experiences (Hein et al., 1998, Damala, 2007b).

Games on PDA are widely used for education purposes not only in museums but also in other formal and informal learning settings and for different scientific domains ranging from biology (Rudavsky, 2003) and forensic sciences (Crane, 2006), to architecture, history of art and archaeology.

Multimedia games created for museum handheld devices can be solitary games (Sauer et al., 2004, Sauer and Goebel, 2003, Bellotti et al., 2004) or team games (Bellotti et al., 2004, Broadbent and Marti, 1997, Brown et al., 2003, Cabrera et al., 2005, Crane, 2006, Hall et al., 2001, Kwak, 2004, Laurillau and Paterno, 2004, Studierstube, 2005, Yatani et al., 2004, Thom-Santelli et al., 2006). Further on, teams can be consisted of individuals (Bellotti et al., 2004, Broadbent and Marti, 1997, Brown et al., 2003, Crane, 2006, Khan, 2004, Laurillau and Paterno, 2004, MIT, 2003, Sauer et al., 2004, Sauer and Goebel, 2003, Studierstube, 2005) or groups of two or more persons (Hall et al., 2001, Kwak, 2004, Studierstube, 2005, Thom-Santelli et al., 2006, Yatani et al., 2004, Cabrera et al., 2005). We could define as collaborative games all team games where different teams or team members have the possibility to communicate in between them. Communication can be synchronous -as is the case with most of the games examined- or asynchronous (Bellotti et al., 2004). Further on, according to Laurillau and Paterno (Laurillau and Paterno, 2004), two kind of collaborative games exist. The first category supports explicitly cooperation and sharing while the second one supports implicitly cooperation through individual activities. We believe that this distinction could be further defined by adding a third category where explicit collaboration and knowledge sharing is demanded between group members and implicit collaboration is expected between different groups participating in the game.

Another distinction can be made according to whether the games played are based on the use of one or multiple platforms (Brelot et al., 2005, Brown et al., 2003, Hall et al., 2001, Sauer and Goebel, 2003, Schmalstieg and Wagner, 2005). Other platforms might include stationary workstations, video projections or other devices such as head mounted displays (Hall et al., 2001). For example, in an austrian project, the reward for the young museum detectives was given in the form of video-sequences clues displayed on a large monitor that made the narrative progress (Schmalstieg and Wagner, 2005).

The place or space where the game takes place can also be used for classification purposes. Three categories can be distinguished. Outdoor games in cities, historical or archaeological sites (Bellotti et al., 2004), indoor games in museums and galleries (Broadbent and Marti, 1997, Brown et al., 2003, Cabrera et al., 2005, Crane, 2006, Khan, 2004, Kwak, 2004, Laurillau and Paterno, 2004, MIT, 2003, Sauer et al., 2004, Schmalstieg and Wagner, 2005, Studierstube, 2005, Thom-Santelli et al., 2006, Yatani et al., 2004) and games that combine tasks that should be accomplished both in an indoor and an outdoor environment (Hall et al., 2001). Outdoor games as well as games combining indoor and outdoor tasks are clearly under-represented.

It is also worth mentioning that the games can take place in a variety of computer environments. By environments here we mean simple 2D environments (Broadbent and Marti, 1997, Cabrera et al., 2005, Crane, 2006, Khan, 2004, Kwak, 2004, Laurillau and Paterno, 2004, MIT, 2003, Thom-Santelli et al., 2006, Yatani et al., 2004, Bellotti et al., 2004), 3D environments (Sauer et al., 2004), mixed or augmented reality environments (Schmalstieg and Wagner, 2005, Studierstube, 2005) as well as combinations of all the above (Hall et al., 2001, Sauer and Goebel, 2003, Brown et al., 2003). The last example can be illustrated by an application designed for the Equator project, for the Mackintosh Interpretation Center, in Glasgow where a shared mixed reality system for visiting the museum was created. Ten group visits of three persons were organized so that for each group, one person was physically visiting the museum using a PDA, while the other two were visiting virtually using a web page and a virtual reality replica of the museum, respectively. All three of them were able to see where the other two visitors were (Brown et al., 2003). Another example, using augmented reality is illustrated by the "virtuoso" project, an application conceived to teach students history of art. The players, using their PDAs, visualize different artworks that have to place in the correct chronological order (Studierstube, 2005).

As for the nature of the games themselves it is important to highlight that they are often inspired by already well known educational museum games. The most familiar of these games are "treasure hunt" games, or observation games where participants have to search in the museum an element, more or less crucial depending on the scenario of the story (Laurillau and Paterno, 2004). Hidden in puzzle pieces artworks as well as scrabbled images or verses the player has to restore (Cabrera et al., 2005) can be considered as digital counterparts of this sort of game. Another type of game, closely related to the aforementioned, is the "mystery" or detective game, where players, individually or in groups have to solve a mystery case which most of the times consists of finding evidence about one or several objects in the museum (Cabrera et al., 2005, Hall et al., 2001, Khan, 2004, Kwak, 2004, Laurillau and Paterno, 2004, Sauer et al., 2004, Sauer and Goebel, 2003, Schmalstieg and Wagner, 2005, Thom-Santelli et al., 2006, Yatani et al., 2004). In some cases, apart from the evidence that can be gathered through observation of the exposed objects, players can also interview characters, use databases or other embodied equipment such as microscopes (Crane, 2006, MIT, 2003). The mystery or detective games are sometimes also using elements from role-playing games, inciting players to choose a specific character and collaborate with other game characters. For example, in the exceptional Questacon-CSI game, conceived to familiarize students with forensic sciences, players are asked to participate in a homicide investigation using one of the following characters: detective, lab technician, forensic pathologist or criminal psychologist (Crane, 2006).

Another interesting scenario was proposed by one of the first PDA projects to be undertaken for the museum environment, as early as 1997. A school group visits a natural history museum. Each pupil takes a PDA. The class is separated in two groups: the predators and the prey. The predators have to identify, using several clues -such as sounds, diagrams, maps- what animals they are and then identify their designated prey in the museum. The prey team is assigned with the same task. When a predator finds its prey or the prey spots the predator the system informs the successful pupil as well as the unfortunate counterpart that he/she has been eaten. The team with the most survivors wins (Broadbent and Marti, 1997).

Sometimes some extra functionalities are added such as taking photographs, or manipulating and modifying 3d objects, as is the case with Dinohunter, implemented for the Senckenberg Paleontological museum in Frankfurt (Sauer et al., 2004, Sauer and Goebel, 2003).

In order to classify the nature of games present in handheld devices used in the cultural section heritage, Belotti et al. (Bellotti et al., 2004), proceeded in a very helpful distinction of three kinds of games: observation games (e.g. reconstructing an image, find the differences or the missing details, answer to multiple choice questions or associate images), reflection games (e.g. answer questions that demand critical reasoning), or video, arcade games that can take a variety of forms depending on the hosting institution. Many of them do not really seem to have an educational value but, as Gee remarks (Gee, 2003), arcade games might help children learn very effectively even if learners are so caught up in their goal that they do not realize they are learning. Computer games can take many forms apart from adventure games. In the surrealist game of Tate Modern, visitors are asked to create creatures by choosing their face, body and feet. In the Dialogue Museum in Belgium, MARIPOSA (Lefftz et al., 2003) features an interactive game for the painting "Cathedral of Pilsen", of Willem Van Gene. Around the main theme many, secondary themes are arranged depicting a variety of topics. They serve as a frame to the work and they are so many that the visitor hardly notices them. The interactive game recreates a new paint by using only the secondary themes and prompts the user to click on each theme. Upon the click the user hears sounds susceptible to be produced in the depicted environments (e.g. a theatre full of people, a train station with a train arriving etc). This example illustrates a game very simple in its conception that redirects the visitor's attention on the exposed work of art (Damala, 2004).

Finally it should be noted that games, as part of the educational material that can be included in a handheld device, can have available features for the pre-visit phase as well as for the post-visit phase. In most of the cases the post-visit related material is received by means of email. Exploratorium in San Francisco (Hsi, 2005), Dinohunter in Senckenberg Paleontological museum (Sauer and Goebel, 2003) and the guide developed for the exhibition "That's Canada" (Duconseille and Rabussier, 2003, Topalian, 2005) provide examples illustrating this approach.

The number of evaluation studies carried out for edutainment material on museum handheld devices is significantly inferior to this concerning the effectiveness of use of handheld devices in the museum setting. To the author's knowledge there is only one available study concerning the effectiveness of PDA delivered educational games in comparison with traditional educational paper and pencil quests. The results showed that the retention of information was almost equal in both cases (Thom-Santelli et al., 2006). Due to the lack of results for assessing the effectiveness of computer aided learning, we find appropriate to refer to an experimentation conducted in South Africa regarding the retention of information relevant with traditional stories of African tribes. Schoolchildren were separated in two teams. The first one listened to a narrator reading a story while the second one was able to experience the story by means of a "cave" installation. Both groups were then asked to fill in gaps and answer questions. Retention of factual information was higher by students who only heard the story but the willingness to find out more about the particular African tribe was much higher among the children that followed the computer-version of the story. This possibly means that children were attracted by the overall setting of the scenes and the storytelling and therefore paid less attention to the actual information. However this experience motivated them a lot in finding out more elements about the tribe (Ladeira and Blake, 2004). These results present some similarities with another experimentation of a PDA guide implemented for the Genoa Costa Aquarium, which set out as a goal to observe whether audio guides or PDA guides are more effective concerning learning. In the questions asked after the visit the group that used the audio guides presented a greater retention of verbal facts while the PDA users performed much better in descriptive tasks (Bellotti et al., 2002).

2.3.8 8TH CRITERION: DELIVERY PLATFORM-TYPE

The proliferation of mobile computing and wireless technologies has led to a multitude of available platforms that can be considered for use in the museum. PDAs are by far the most common platform, selected for the majority of related projects. A first distinction can be made in between Pocket PC and Palm OS operating systems. Pocket PCs are the most widely used in museums. They are more expensive that Palm OS but they have larger screens, higher resolution and support the landscape mode. Palm OS on the contrary are cheaper, have a longer battery life but support only two ways of text entry instead of four supported by Pocket PCs and have a less good support for rich multimedia files (Raptis et al., 2005).

The main disadvantage of PDAs is the small display that can render difficult the interaction with the guide and the level of immersion in the proposed multimedia content. This is why Tablet PCs have also been employed as terminals for the delivery of multimedia guided tours, as was the case in the Dialogue Museum, in Louvain La Neuve, Belgium and Danae project (Lefftz et al., 2003). Some of the advantages are the available interaction surface, greater processing and memory capabilities, while they can be used simultaneously by more than one user. On the contrary, one of the main disadvantages is that Tablet PCs are much heavier and therefore less practical to carry even if straps are attached (Figure 2.8c); at the same time the cost is at least double compared to the cost of a PDA guide. Lately a new type of handy personal computer has made its appearance: Ultra Mobile PCs or UMPCs. UMPCs are dotted with all the power of Tablet PCs but are considerably more expensive in comparison with these last, at about 30 to 40%. The main

Augmented Reality prototype proposed in this study was delivered in two different types of UMPCs (Figure 2.8b).

Figure 2.8a-2.8d: Existing alternative (other than PDAs) mobile platforms for the delivery of multimedia guided visits. From left to right: Use of a mobile phone (Pian et al., 2004), a UMPC (Damala et al., 2008), a laptop (Lefftz et al., 2003) and a Tablet PC (DANAE project).

A 4th candidate platform is cell phones, which are anyhow converging towards multimedia capable computers. At least two case studies have used mobiles to deliver context aware information concerning exhibits. In the city museum of Weimar, mobile phones were used together with a pattern recognition module by the AR research group of the Bauhaus University (Bruns et al., 2005). In the United States, an xml-based system was used to convert common mobile phones to audio guides, as part of a university project (Samis and Pau, 2006). Using a mobile phone as an audio guide though is not a new idea, as France Telecom RD has been conducting experiments of that kind from 2002 (Damala et al., 2005). Today a commercialized version of a city guided tour is available for tourists equipped with mobile phones in Paris. Finally, the delivery of audio comments on visitors' self owned mobile phones was experimented by (Nickerson, 2005).

2.3.9 9TH CRITERION: PLATFORM OWNERSHIP

The introduction of highly sophisticated systems as guidance support in the museum premises comes with a high price. Even admitting that all current challenges discussed in section 2.5 are addressed, buying or renting, storing, maintaining, distributing and recharging the devices can cause frustration and difficulty to deal with overheads. This is the reason for which the alternative of delivering multimedia interpretation material in visitors' self owned terminals might steadily gain ground in the future compared to other approaches (Samis, 2007).

The delivery of audio in visitors' self-owned terminals, like mp3 players or mobile phones, has already appeared. In this scenario, either the visitor downloads prior to the visit the uploaded on the museum web site audio commentaries, as for example in the case of San Francisco Museum of Modern Art (Samis and Pau, 2006) or in the Museum of Fine Arts in Rennes, or receives via his mobile phone audio comments once on site (Nickerson, 2005). Concerning the delivery on visitors' self-owned cell phones, experimentations with more demanding multimedia content have also made their appearance. This is the case of Agamemnon project (Figure 2.8a), an outdoor guide for assisting in the visit of Archaeological sites (Pian et al., 2004) and of a project undertaken by researchers of the Bauhaus university in Weimar who are experimenting with camera equipped mobile phones and on-device object recognition (Föckler et al., 2005). Not only costs and expenses could be cut down this way but as visitors have themselves stated, using one's self owned terminal might also cut down on the learning curve needed for comprehending how to interact with a mobile device (Woodruff et al., 2002).

2.4 THE MOBIVISIT PROJECT

2.4.1 SCOPE OF THE PROJECT

The Mobivisit project is a combination of an indoor and outdoor portable tourist guide that set as a goal to examine the continuity of usage of a tourist guide in indoor and outdoor environments. In this sense the indoor guide, Mobiguide, which at the same time constitutes a mobile multimedia museum guide, was an extension to the core Mobivisit project, which got finally commercialized with the form of a tourist guide for the city of Paris. The first experimentations took place in Lyon, in 2003, on PDAs in order to conduct usability tests regarding the use of the guide in the city, the surrounding regions as well as in the museum of Fine Arts in Lyon, who was the museum partner of this project. The museum's permanent exhibition is comprised of around 3000 objects exposed in seventy exhibition rooms on three different levels.

2.4.2 PROFILE OF THE MOBILE MUSEUM GUIDE

Applying the nine criteria described in section 2.3 allows the profiling of the mobile museum guide module implemented in the frame of the "Mobivisit" project. The guide was multimedia capable, as it featured text, audio, images, and interactive plans of the museum galleries, stitched together in a Flash application. It used a declarative geolocalization module further described in section 2.4.5. The experimental module concerning the museum was an offline application, combined with an online application for the outdoor services. In terms of personalization, the guide offered the possibility of thematic tours as well as tours according to the time available for the visit. The social or collaborative character of the visit was not examined separately and no dedicated modules were designed and implemented. Instead, the focus was on the continuity of usage in between the indoor and outdoor modules. PDAs were used as delivery platforms for the indoor, museum guide but for the outdoor guide experiments were also conducted with SPV cell phones. The possibility for tourists/museum visitors to use their own mobile platform was another issue that was examined throughout the project.

2.4.3 HISTORY OF THE PROJECT AND DESIGN PROCESS

In France Telecom's R&D division, the first investigations in the field of handheld tourist guides started as early as 2001, through a series of interviews that set as a goal to investigate the type of services that could be proposed in the tourism domain. Following these interviews, a video scenario was created, featuring a tourist during an outdoor visit. Several communication functions were identified through this process and were then included in a storyboard. Based on this animation, several prototypes were tested, first in the laboratory and then under real conditions. After the end of the experimentations, France Telecom worked jointly with the French Regional Tourism Committee of Paris-Ile de France, to develop an experimental Mobivisit for Paris, on a mobile phone platform (SPV) that would be rented through Tourist Information Offices. Using the experience gained from the first experimentations, the service was opened to the Orange Gallery portal and is now operational for a variety of terminals and in many different languages.

As the decision to implement and test a multimedia museum guide was not conceived from the beginning of the project, three months were only available for the full process of design and implementation before the first release and the consecutive experiments took place. Despite the fact that the texts chosen for the guided tour by the museum conservators had been based on texts created for an audio guide, the full process until the final validation of the content was quite long. When the content was ready, it had to be translated in English before the recording of the audio sequences took place. As a general rule, each commented object was accompanied by an audio commentary of less than three minutes. Apart from the accompanying photo of each commented work, text was also provided; the available text either reproduced museum objects' etiquettes or introduced additional to the audio sequences comments. For a total of 40 museum objects, 60 minutes of audio commentary was available. Subsequently, a FLASH application was created, described in more detail in the following section. Unlike the outdoor companions of the guide, the museum application would be stored locally. Despite the fact that the PDA used had integrated loudspeakers, the audio was delivered through headphones, so that other visitors don't get annoyed. The Hewlett Packard PDA used had GPRS capabilities and a memory extension.

2.4.4 DESCRIPTION OF THE GUIDE AND NAVIGATION SCHEME

The introductory scene of the application proposes three options, four if we also count the possibility of switching the language from French to English and vice versa. The 1st option, "Concerts in the Garden", proposes an accompanied by music visit of the museum gardens. The "Visit the Museum" option opens up a new menu (Figure 2.9), while the "Find the museum" option provides practical way-finding information. Finally the activation of the "headset" button launches a small audio presentation of the museum building.

Once the "Visit the Museum" option is activated, a new menu comprised of four options is proposed to the visitor: The "Information for Visitors" offer visitors practical information about the museum and visiting hours. The "Special Exhibition" section includes information about temporary exhibitions held in the museum (Figure 2.9).

The options "Plan of the Museum" and "Collections and Visit" propose two alternative ways for navigation in the main content of the guide. In the first case the visitor can choose between one of the three annotated plans of the museum (one per floor), create a personalized list choosing proposed exhibits and proceed with the visit. The commented works will appear on the plan with the form of grey squares. In the second case the visitor has the possibility to choose between:

Figure 2. 9: Mobivisit project, Screenshots of the mobile museum guide, Museum of Fine Arts, Lyon (Damala et al., 2005)

-The "Recommended Visit": This visit comprises all forty exhibits that are included in the tour.

-The option "By Selected Topic", hosting thematic tours.

-The "Minutes" option: This option gives visitors the possibility to choose a proposed tour, using as a criterion the available time for the visit. The guide proposes thematic tours of half an hour, an hour and an hour and a half.

- The "Set Up our Own Visit" option, described above.

Regardless of the way the visitor chooses to proceed with the multimedia tour, the layout of the information accompanying each exhibit is consistent and follows the same guidelines, so that the visitors don't get confused once they have become familiar with the system. Each work included

(Figure 2.10) in the visit, is accompanied by a picture that can be zoomed in, an icon showing the size scale of the exhibit, a text button, when text is available, a headphones button for access to the audio commentary as well as a forward and back button used for jumping to the next or previous commented work.

Visitors can also click on the little square above the picture to indicate that they are "done" with an exhibit (they have seen it). If this action is taken, the museum plan is updated with the already viewed work of art that gets marked with a cross. On the top of the screen the icons used are the "Home" button, the "Back" button (return not to the previous commented work but to the previous screen), the "Geolocalization" button and the "Search" button, that enables the visitor to search works of art according to three different criteria (type, period, artist). There is also the "Help" button and a "Close the Application" button. Finally the option "On layout" shows where exactly the consulted exhibit is located on the map.

Figure 2.10: Mobivisit project, Examples of exhibit presentations (Damala et al., 2005)

2.4.5 GEOLOCALISATION IN MOBIVISIT

Starting with the principle that geolocalization modules provide an invaluable aid in museum visiting, several technological solutions were considered. The RFID, Infrared and WI-FI possibilities were ruled out for reasons such as the restrained time frame and the available budget. The solution had also to be the least invasive concerning the aesthetics of the museum environment.

Eventually a hybrid solution was proposed: Physically the museum walls were signposted with special logos indicating the exhibits included in the guide. At the same time, the application itself proposed two other possibilities. The first one was the "Geolocalization" button which, once activated, prompted the visitor to fill in a form consisting of three different fields (Figure 2.12).

The first field is "View" (e.g. garden, roof and chapel). When the first field was filled in, the list corresponding to the second field, "exhibit", was displayed. The same process was repeated for the third field, named "period". The visitor then obtained the corresponding floor plan with his estimated position given in a flashing square. A second element of the guide assisting visitors in geolocalization was the option "Plan of the Museum", which we already met in the 2nd level navigation of the application. When this option is activated a new screen appears, presenting the three different exhibition levels (Figure 2.12b). The visitor is then expected to choose one of the floors. When this happens, a plan of the selected floor appears on the screen. Gray squares indicate the exhibits, included in the multimedia tour, while it is possible to zoom on the map. This form of visiting requires the visitor's ability to decode the plan and understand to which section of the plan that he/she sees corresponds. For this reason additional signposting was used, indicating which of the works exhibited are included in the multimedia tour.

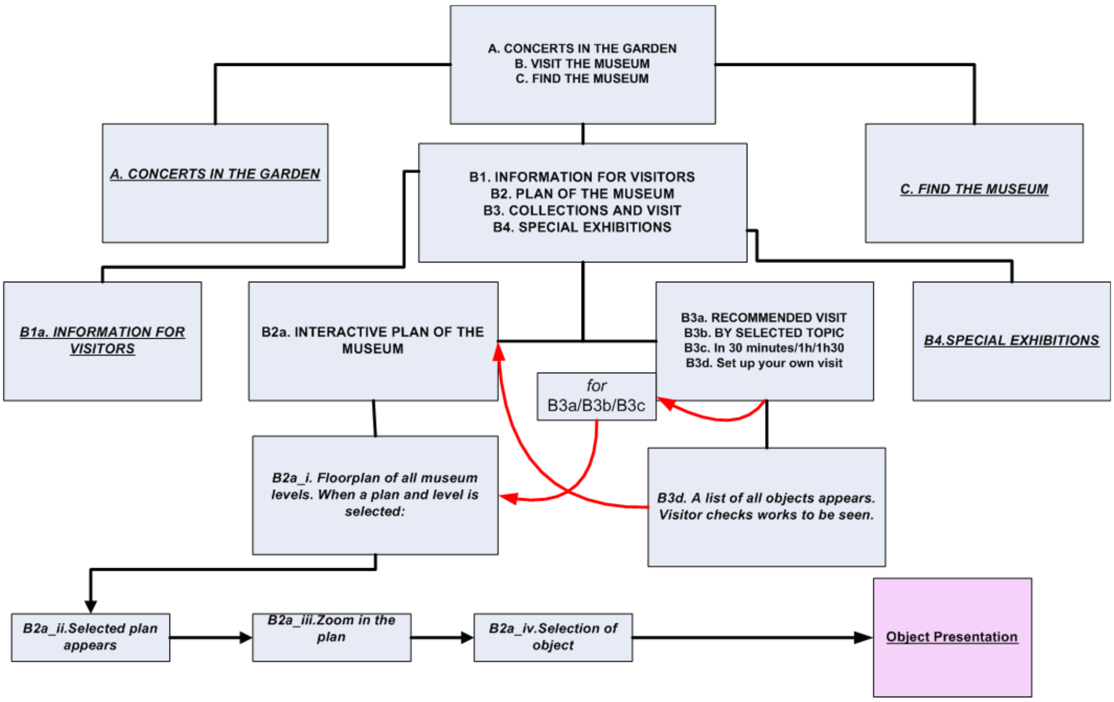


Figure 2.11: Mobivisit project, Navigation flowchart

2.4.6 TESTING AND EVALUATION OF THE GUIDE

During the first three months of the experimentations, approximately 500 tourists borrowed the multimedia guide from the main Lyon Tourist Information Office to test it free of charge, for a period of one to three days. A second experimentation took place in the museum, with three different target groups: tourists, students and "Friends of the Museum", namely senior citizen visitors. In order to test the effectiveness of both the indoor and the outdoor multimedia guide, both quantitative and qualitative evaluation methods were used. Quantitative evaluation included surveys and logging visitors actions, while for the qualitative evaluation, visitor's observations were combined with interviews (Le Coq et al., 2003).

From these 500 visitors, 232 visitors filled in and handed back the survey concerning the use of the guide. According to the logs obtained for these users, the average museum visiting time was about 40 minutes. One of the features most appreciated by the visitors was the possibility given to organize the multimedia tour according to their available time. The possibility to undertake thematic visits was also highly appreciated. On the contrary, many visitors expressed their frustration for finding out that several works were not present as a result of a loan or restoration. Some of the less used provided features were the "Help" function, the "Search" function and the "Mark as seen" function.

Figure 2.12: Mobivisit project, the fill-in form used for geolocalization and snapshots of the interactive museum plan (Damala et al., 2005)

Another group which consisted of 93 visitors was observed during their museum visit and was then asked to fill in the same survey as the aforementioned group. The observation data was then combined with the data logs, as well as with the questionnaires filled in. The average time this group spent with the guide was 50 minutes and the average number of audio sequences heard was 41. The "recommended visit" was chosen by 57% of the participants. 25% chose to use the "Minutes" visit, (visit according to the time available). 25% of them personalized their visit while only 3% used the proposed thematic visits.

Finally, observation and in depth interviews were conducted with 35 "Friends of the Museum" visitors, that were tourists, students or seniors. The interviews were transcribed and examined individually and in correlation. This group of visitors, presumably because of their particular interest in art, spent an average of 2 hours in the museum using the "Recommended Visit" option that includes all exhibits. The average duration of the audio comments heard was about 60 minutes. This is a very interesting finding as it might be an indication that this group of visitors also contemplated during their visit not-included in the guide works of art. Despite a 5-minute demonstration, some of the visitors, mainly senior citizens, had some difficulties in understanding how to use the guide. All participants mentioned the geolocalization module but not always in a positive way. Some of them stressed out that they did not arrive to easily identify the objects included in the guide on the plan. It is maybe for this reason that the majority of visitors mentioned using simply the photos of the works in the guide and the museum signposting as a mean for orientation. As to the quality and length of the audio commentaries, many participants pointed their approval for the use of both male and female voices. The "text" feature on the other hand, was not considered to be helpful when it just reproduced the museum label text, but only when it contained information going beyond the audio commentaries. The majority of the interviewed visitors mentioned that they liked the graphical user interface (GUI). Finally 9 out of 35 participants expressed their wish to see a strap attached to the Pocket PC so as to free their hands and protect the terminal from accidents.

2.4.7 LESSONS LEARNED AND ISSUES DETECTED

Mobivisit is a project that put under questioning, the continuity of usage from outdoor tourist guides to indoor - content and context specific - handheld guides. However the life cycle of the project and the evaluation undertaken after the completion of the projects provides some useful hints concerning the techniques of creation and implementation of a mobile multimedia interpretation medium for the museum environment. This issue will be also further examined in the dedicated 2.5 section, where barriers to overcome are examined.

Geolocalization: Despite the care taken, it seems that in terms of geolocalization more progress and innovation is necessary. Most of the visitors interviewed criticized with one or the other way the performance of the geolocalization modules. It is worth noticing here, that even most of the "Friends of the Museum" visitors though more familiar with the museum premises preferred the photographs over deciphering the interactive museum plan as a navigation aid.

An **Interdisciplinary collaboration**: As with other projects an interdisciplinary collaboration was needed. As mobile museum guides are still far from being the norm in museums, museum partners are often not completely aware of the palette of the possible functions or utilities this new medium possesses. Ironically what is also true is that museum multimedia guides can be as various and diverse as museums and museum displays are. In the case of Mobivisit project, the time needed for the internal (museum) validation of the presentation content and the scenario, was disproportionately long compared with the total duration of the museum project.

Human resources and management issues (logistics): Several important remarks are related with the issue of the distribution of the guides. More in particular, the museum employees on-site were quite reluctant in assuming responsibility regarding the distribution of the guides, recharging the batteries etc. This was less of a denial and more a particular stress as to the possibility of doing something inappropriate that would damage the devices. This provides an additional reason for exploring the possibility of use of visitors' self-owned platforms. Not only the cost could be considerably lower, but fewer personnel would be needed, while visitors would presumably be more at ease using their own terminal. Human resources issues were also one of the reasons for which the project of the Museum of Fine Arts in Lyon was discontinued.

Costs: From the full design and implementation process, it became apparent that appropriate financial resources are compulsory. Mobile multimedia guides in the museum setting are not "money makers" and apart from costs regarding the design and implementation phases, investment is also necessary for buying the terminals, maintaining the system and updating the content. In terms of visitor support additional personnel is needed to hand out the guides, explain their use and recharge them. In the case of the museum of Fine Arts in Lyon, this was a detail that became apparent as soon as the application was ready to be tested by real visitors. The already existing personnel was hesitant as to whether it could be of any assistance and eventually was not at all implicated in the experimentations.

Evaluation: A methodological and data integrity issue arouse after the beginning of the experimentations. As already explained the system logged visitors' actions for evaluation purposes. However, it soon became apparent that as visitors borrowed the guide from the tourist information office for a period of 1 to 3 days, there was no easy way to tell whether the log files obtained corresponded to a museum visit or to an off-site consultation. Methodological issues regarding the evaluation of mobile museum guide projects are examined in detail in Chapter 5.

Personalization: The comparison of the visiting patterns among the "Friends of the Museum" group and the other participants showed that different visitor profiles demonstrate different wishes and needs, regarding the duration of the visit and the level of detail demanded by the accompanying information. In the case of the Museum of Fine Arts in Lyon the average visit time for the "Friends of the Museum" was two hours, as in contrast with the 45 minutes in average spent by the rest of the participants. The fact that the total duration of the content of the guide was around 60 minutes, demonstrates that the "Friends of the Museum" group also contemplated objects not included in the multimedia guide.

Continuity of Usage: As the investigation concerning the continuity of usage between outdoor and indoor applications continues, it becomes more and more apparent, that special attention should be paid to the design and implementation of more generic interfaces and solutions. In the future, this could allow the users to use their own platform, decreasing the costs dramatically. At the same time a better continuity of usage could be established, combining for example, indoor, outdoor and home usage. In this scenario the application presented on the mobile phone or Pocket PC, could be linked to the museum web site content, and could possibly be consulted from home thus encouraging a long lasting relationship between the museum and its visitors.

However the possibility to create a generic system for all museums is still an open question as each museum is unique not only in character and nature but also in policies, human resources, available funds etc. A standardization process would ideally regroup all interested members of the involved communities, including museums, IT companies, and governmental bodies. And while standardization for museum documentation purposes is already on the way (CIDOC, 2006), standardization for museum educational applications on handheld platforms has never – to our knowledge- been considered.

The creation of a generic system would also allow museum staff to keep the multimedia guide content up to date, and museum visitors to communicate with friends inside or outside the museum. The navigation should be as easy as that of a mobile phone, while financial contribution for the provided services could take the form of a subscription to the specific service. In order to roughly summarize the advantages and disadvantages of each solution, the following table (Table 2.1) was dressed.

Table 2.1: Advantages and disadvantages of using museum provided and personal terminals (Damala et al., 2005)

	Museum provided terminal	**Personal terminal**
Scenario	Museum specific (can be)	Generic (has to be more)
Application	Rich in multimedia	Platform dependent
Navigation type	Complex	Platform dependent
Advantages	Advanced, up to date technologies Possible continuity of usage	Less up to date technologies, Continuity of usage
Disadvantages	For use only in the museum, battery life to be constantly checked	Less advanced technologies, network verification
Software and content updates	Easy and frequent	Easy and frequent
Storage capabilities	High	Low
Continuity of usage	Weak	Indoor / outdoor / home
Configuration	Standard configuration	Possible complications
Cost	Costly solution	

2.5 THE DANAE PROJECT

2.5.1 SCOPE AND HISTORY OF THE PROJECT

DANAE (Dynamic and distributed Adaptation of scalable multimedia coNtent in a context Aware Environment) is a concluded IST European co-funded project that ran from January 2004 to June 2006 with a goal to specify, develop, integrate and validate a complete framework for the delivery of rich multimedia content to a variety of end-devices and with a minimal cost to the end-user. A total of 11 partners participated in the project which counted considerable contributions in the domain of the MPEG4 and MPEG 21 standards (DANAE, May 3, 2006). All technological bricks developed were more or less successfully integrated in a mobile multimedia guide created for Museon museum in Den Hague, Netherlands. The following sections explain in detail how these technological innovations may in the future influence the functions and possibilities provided by mobile museum guides.

The author had the possibility to participate in the process of the conceptual and interaction design of the guide, from October 2004 and until the end of the project. A first important remark is that the cutting-edge, technology-oriented character of the project seemed to overshadow the actual requirements analysis phase that the particularity of the selected museum environment imposed. This does not mean that scenarios and innovative uses were not conceived and then implemented but rather that often enough these scenarios had, somehow, to seriously take under consideration how to incorporate an already under implementation module in the museum application. Therefore, the first action undertaken by the author was to establish a communication channel with the only museum representative and define the profile of the museum in which this intervention would take place.

2.5.2 MUSEON HISTORY AND PROFILE

Museon museum was founded in 1904 as a private organisation. In 1920 it became public and was taken over by the municipality. Nowadays it has taken the form of a non-profit private foundation supported mainly by the local municipality (municipality of The Hague). The Museon's collection consists of about 250,000 objects, 85 000 of which are digitally documented using "The Museum System" (Gallery Systems) commercial software used for museum documentation.

The museum has a very strong educational orientation, which largely defines many of the activities undertaken. In temporary and permanent exhibitions, the exhibits are mainly chosen for their educational value. The museum also encourages all kind of interpretation activities and even “dares” to involve visitors in a public dialogue around objects and ideas through the use of interactives such as polling systems. Apart from the multimedia guide other media used to reveal the narrative apart the exhibits themselves are panels, text labels, printed material, and multimedia applications ranging from videos to interactive collaborative games etc (Figure 2.13).

The museum has a web site constructed by an external, private company and maintained internally (www.museon.nl). Press releases are published periodically. The museum also maintains a close relation with its volunteers and members of the Association of Museon Friends. Some guided visits are given by volunteers, while the museum shop is mainly functioning with volunteers. The predominant profile among Museon visitors are parents or grandparents with children and school groups, though of course other profiles are also largely represented.

DANAE project coincided with the museum renovation of the permanent and semi-permanent exhibition spaces. The new exhibition space, for which the guide would be designed, would be comprised by 1000 m^2 of unified exhibition space, surrounded by eighteen 100 m^2 spaces. In these new exhibitions the multidisciplinary and educational character of the Museon is fully expressed. Around 90 terminals with interactive multimedia content would be also installed in the exhibition area (Figure 2.13). The content of these multimedia kiosks ranges from arcade games to video and slideshows that can be consulted in combination with MuseOnline, a system that, upon registration, uses bar codes to identify different visitors, keep a track of their visit and save the data for later consultation via the World Wide Web, creating a unique web page for each visitor.

In this already well-thought and rich in interpretation resources environment which could be the added value of a mobile multimedia guide? According to the principal museum representative, Hub Kockelkorn, some key characteristics and advantages of a mobile multimedia guide over more traditional methods (text commentaries, paper books, audio guides, docents, information kiosks, other stationary multimedia installations etc) are the greatest capability for content personalization, the possibility to potentially deliver unlimited information to the visitors, and taking a step forward from the classical audio guides. As we will see later on in case study of the museum of Fine Arts in Rennes (Chapter 4, 5 ,6, 7), Museon believed that the new guide might attract new visitors and help the museum in establishing a long-lasting relationship with the visitors, by intriguing imagination, facilitating learning, and encouraging public dialogue around exposed objects.

Figure 2.13: Interactives used in the permanent "Your World, my world exhibition", Museon museum, Netherlands.

For Museon, the ideal mobile companion should be something between an e-docent and a virtual guide, allowing the visitor to "dig-in" the content according to his wishes and needs. As is the case with other museums, the question of whether there would be "potential competition between the actual exposed objects and the guidebook" also constituted an issue to be examined. Concerning the number of available terminals that would be necessary in case the guide was adopted for real use in the museum, an estimated number of 30 to 40 terminals would be needed.

2.5.3 ARCHITECTURE OF THE MULTIMEDIA APPLICATION

The goal of the DANAE project was to design a platform for context-aware dynamic multimedia content adaptation. The content was defined in terms of interactive scenes of the museum multimedia guide that would allow the visitors to navigate in a potentially complex page-hierarchy, mixing text, avatars, audio, video and still images. "Context", for the project purposes, was defined as visitor's location in the museum, preferences, terminal capabilities (e.g. PDA, tablet PC, projection screen) and allocation of network bandwidth according to the number of other sessions run by other visitors, equipped with other kind of terminals (Figure 2.14).

The adaptation involves a client (located at the end-user terminal) which collects the user context and requests multimedia scenes. All adaptation decisions and actions are taken by the server which is able to modify the way content is presented by changing the layout, the type of media and their bitrates. For instance, a scene adapted for a PC will have a horizontal layout including large portions of text and high bit rate video. The same scene adapted for a PDA will have a vertical layout with audio instead of text and low bit rate video.

When the player requests from the server a specific multimedia content, an MPEG-21 based representation of this content is used to compute the best adaptation according to the data stored in the context repository. The "Optimizer", a key module inside the adaptation architecture, will first select the right media according to the user preferences (like audio vs. text), terminal capability (like available codecs or video size matching the devices) and available network bandwidth. Once the adaptation decision is made, the "Optimizer" creates and sets up the media adapters corresponding to each stream being adapted. Then the media delivery from server to multimedia player can start.

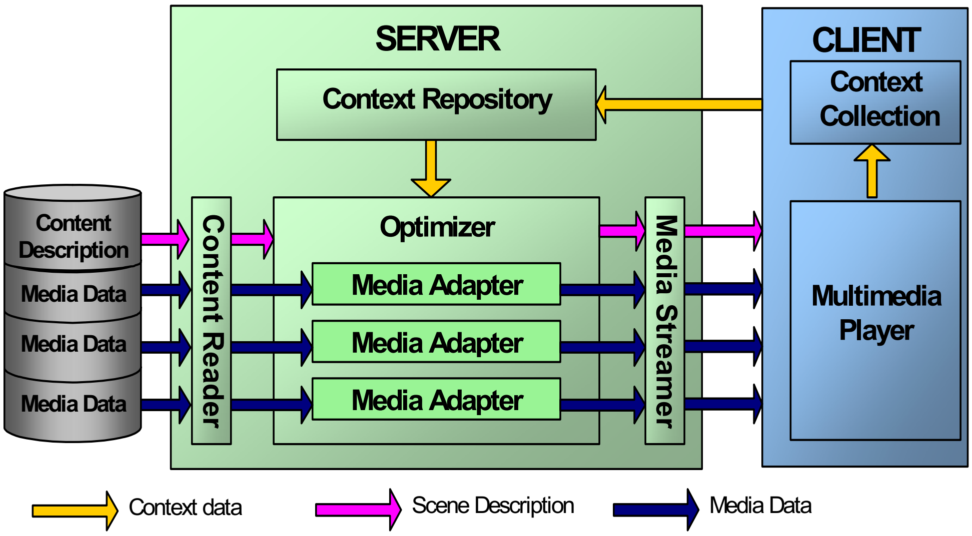


Figure 2.14: DANAE project, simplified adaptation architecture (Brelot et al., 2005)

During the session, the context may vary over time: the network characteristics or the player performances may decrease or increase (for instance the number of visitors connected to an access point may limit the available bandwidth). This will induce a context modification at the client side which will forward this information to the server via the context repository. This information can be used to re-allocate a new bandwidth to each media by modifying the relevant media adapters' settings. Further, if the changes are drastic enough, the Optimizer may compute a new layout with eventually new media.

2.5.4 A POSSIBLE USE SCENARIO

The following scenario was one of the initial inputs for the application specification and design, conceived by the museum representative. As we will see, not all of the functionalities were implemented. Nevertheless, by reproducing here the initial scenario we are able to understand in which ways the mobile guide could be integrated in the museum.

"Hans and Iris Jansens and their two children Anna and Nicolaas arrive all together in front of the new Museon exhibition entrance desk where several assistants are waiting for. One assistant invites the family to come closely. He starts explaining the different themes of the new exhibition. He also proposes them to use new mobile guide devices that will help them to have a complete and full experience of the exhibition and to dig interactively as far as they want into thematic, specific creations, history and usage of exposed objects. Fully convinced, the Jansens family agree

to use those new devices. Iris and Hans decide to get a PC tablet while Anna and Nicolaas take a PDA-like device.

Before entering the new exhibition, the assistant advises the family to take few minutes to first register by completing the first form (name, age, language) and to make some choice according to what they want (thematic, time to visit, knowledge level etc). Then, they start listening carefully the introduction presentation that explains how to use their device. Anna and Nicolaas are very amused by the funny 3D character that appears in order to explain some points more in details. Guided by their mobile device, the family starts walking towards the "everything changes" theme space. As soon as they arrive close to the targeted space, their mobile guide pops up summary information and a map of the room. Then, each member of the family is discovering topics at their own pace.

They quickly realize that the mobile device is much more than a classical audio guide. Indeed, it allows to dig into subjects by showing movies that can be paused, forwarded etc, to come back to the main menu and get complementary desired information, to ask questions to the expert 3D character. Moreover, popup windows ask them to express what they like (creation, topics and other things).

Anna and Nicolaas move faster than their parents through the new exhibition and they are discovering by themselves new space. They understand easily how to use the mobile guide and take pleasure in navigating into the mobile applications which is full of funny and interesting information (movies, texts, and explanations from the 3D character, panoramic pictures of some situation or place).

Iris and Hans are very impressed by the different functionalities offered by the mobile device. One of them seems magical. Indeed, arriving in front of a wall panel showing information about specific past civilizations, they realize that their mobile device automatically shows the same information and movies on their own tablet. Moreover, they are able to transfer the videos they are watching on their terminals to the much larger panels, enjoying thus a better quality in image and sound. They can also transfer multimedia content playing on the stationary multimedia kiosks on their terminal, so as to watch them privately using the functionality of session mobility (Figure 2.15a).

Suddenly, Iris wonders where Anna and Nicolaas are. Hans reassures her by showing her the museum map and the interesting functionality "localize your buddies". Immediately, they know that Anna and Nicolaas are already at the museum store. Very happy of their visit, Iris and Hans catch up with Anna and Nicolaas at the store. Their children run at them and ask them to go to the media postcard room just next to the store. The media room allows several people to realize their own video or photo postcard with the topic they want. Nicolaas wants absolutely to choose a video sequence of a T-Rex dinosaur running at them. So, they all act to as if they are very afraid during the 10 seconds of the sequence. Then, the 3D character explains that the video postcard is available through the web site of the museum. A specific access number will be given to them at the exit when they will give back the mobile devices.

Very amused, the family walks back through the store. Iris and Hans realize their tablet PC starts presenting a consistent summary of their visit: what they saw, what they liked the most. Then, the 3D character appears and invites them to have a look on to specific books, DVD, postcards or T-shirt they may like according to the content they consulted during their visit.

Back home, Nicolaas insists to go at once onto the museum website to see (and download) the terrible sequence they did with the T-Rex. Everybody laughs so much when they see the T-Rex sequence. Just after that, Hans realizes the website is full of interesting information. It's possible to get summary information from their last visit, to watch on a map the path each of them followed in the museum exhibition, to have access to all of the museum shop items and to buy them on line. Moreover, the website presents future activities of the museum (new rooms, next exhibition) and also gives access to live conferences with world experts on specific subjects. Already amazed, Hans discovers the fantastic virtual tour of the museum (panoramic pictures and videos full of interactive hyperlinks to other contents)."

The initial stage of the project had foreseen the creation of content for two different target groups, children under 12 year old or adolescents and adults, in two languages, Dutch and English. Eventually however, only one tour was possible to be implemented, suited to adults.

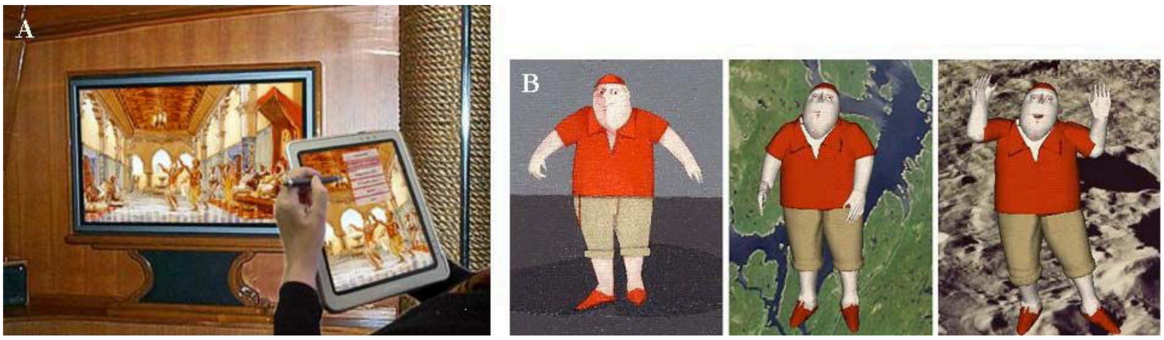


Figure 2.15a- 2.15b: DANAE project, session mobility function (A) and one of the DANAE avatars (B) (to the left the original design by Jean-Marie Boomputte, to the right two screen shots of the 3D-rendered avatar)

2.5.5 CONTENT STRUCTURE, APPLICATION DESIGN AND NAVIGATION

The interface of the application as well as the navigation schemes were largely influenced and inspired by the study of the new exhibition space. The exhibition, entitled "Your World, My World" would be comprised by 12 different themes treating the story of human development under many different aspects, from the first appearance of life on earth to world religions and energy forms. Each of these themes would be further decomposed in different sub-themes. Therefore, all included objects would belong to a main theme and most of the times also to a sub-theme. The interface and navigation scheme eventually chosen, reflected the physical but also contextual exhibition organization so as to render the exhibition narrative clearer but also so as to create bonds between the physical and digital displays. An avatar, designed by the Belgian artist

Boomputte (Figure 2.15b), would provide an introduction for every theme and subtheme (Figure 2.16).

As with most museum exhibitions, Museon's exhibition could not be considered as a collection of single objects. The majority of the objects on display serve primarily for the illustration of a story that unfolds through the interrelationships of the objects on display. In the exhibition, selected chapters from the history of Earth to Mankind would be presented, focusing on topics like geological processes, evolution, oceans and wetlands, evolution of man, archaeology, energy, warfare, religion and the creativity of mankind. The eighteen separate spaces are used to enter into selected separate aspects of the story narrated in the main exhibition (Figure 2.17a).

The above graph demonstrated how the navigation pattern emerged by examining the structure of the exhibition. It depicts the underlying structure of one of the exhibition's themes, dedicated to birds and mammals. This theme is divided in different sub-themes or narratives. In the exhibition space, these narratives are expressed by a group of objects serving as visual statements. In the same way, the guide's interface reflects this structure. Each theme is divided in sub-themes. Each sub-theme proposes additional information for selected exhibits. The information may have the form of text, audio, video, image, animation or a combination of these elements.

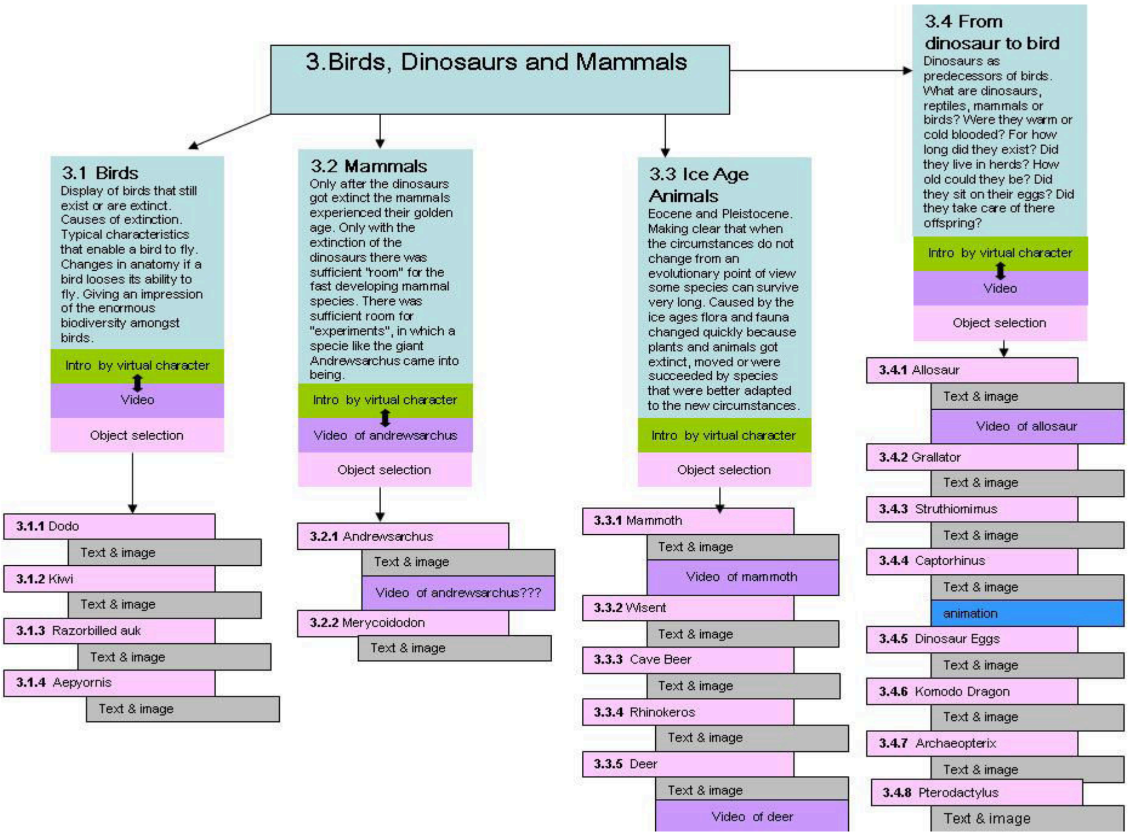


Figure 2.16: DANAE project, the content representation graph

For every theme an introduction is proposed, and then the different themes with their respective introductions follow, before the visitor finally reaches the object level. This proposed by the author structure is also reflected on the interface design for a tablet PC, shown in figure 17b. To the right part of the screen, we see in form of tabs, the different themes available on the guide. Each time a visitor enters a new theme, the Wi-Fi system communicates with the terminal. A white circle starts flashing to indicate that new content is available and waits to be activated by the visitor. On the top right of the screen, we see the map application that can be used to locate other companions, registered during the registration process simultaneously.

2.5.6 CONTENT AUTHORING FOR MUSEON'S MOBILE GUIDE

The content creation in DANAE was based on an XML format that describes the layout and styling of the multimedia scene, the embedding of media components as well as the interaction. Among the media components defined in this language, one can count text, audio, images, video but also panoramic images and slideshows. The XML document and all the necessary resources for rendering the scene are then compiled in a binary MPEG-4 representation for the delivery on the mobile device. The benefits of this approach were that high-level constructs are used in a manner close to HTML authoring which is well-known to many authors and that MPEG specifics are hidden from the authoring process. For audio and video, only one encoding for each audio and video resource is necessary. The MPEG-21 metadata also defined in the project makes the server dynamically extract the audio and video adapted to the available bandwidth and display size.

2.5.7 PROPOSING AN EVALUATION FRAMEWORK

Evaluation with real visitors was planned in the case of DANAE and took the form of a separate deliverable, examining all possible methodological solutions and approaches, together with their advantages and disadvantages. Apart from designating appropriate for the evaluation of the guide methods, the work carried out strived to better approach and comprehend the meaning of effectiveness regarding relevant mobile guides in the museum setting, which is often the only common point shared in evaluation studies. Unfortunately the evaluation itself was finally not realized due to the tight budget and the time constraints regarding the completion of the project.

However and even though evaluation was finally not possible to be carried out, the review of related literature and practices resulted in a taxonomy regarding evaluation issues that may arise during the deployment of a mobile museum guide project. The proposed taxonomy as well as methodological considerations regarding evaluation for mobile guides in the museum setting are examined in depth in the 5th chapter.

Figure 2.17a-2.17b: DANAE project: Plan of the new exhibitions area (A) and the corresponding user interfaces created for the TabletPC delivery (B) (Brelot et al., 2005)

2.5.8 LESSONS LEARNED AND ISSUES DETECTED

Despite the fact that the DANAE project was mainly focused on strategies for delivering rich multimedia content in a large variety of platforms and devices, several of the issues that came forth during the design and implementation of the guide, are closely related with general issues that may arise during the process of design and creation of mobile guides for the museum environment.

Geolocalization: The use of Wi-Fi was successful enough to give the visitors their position with a granularity of about 1,5 to 2 meters. Taking under consideration the overall layout of the exhibition, composed of themes and corresponding subthemes, these results can be considered encouraging and quite helpful in case a visitor wants a rough idea regarding the theme area in which he/she is found. However, as with Mobivisit project, the system was less helpful regarding orientation and physical navigation at a museum-object level.

Costs: In order to achieve the 1,5 to 2 meters granularity, a fully functional wireless system had to be placed in the museum. Unlike the first estimations regarding the number of Wi-Fi access points, the number in reality had to be doubled. Museum representatives were also quite skeptical about the costs for buying or renting the devices, charging them, maintaining them and providing personnel to assist visitors with information regarding their use.

Interdisciplinary collaboration: The interdisciplinary team involved and the size of this 11-partners project was quite disproportionate in comparison with the work-hours needed for the final application content authoring and creation. A wealth of "rough" material was available from the educational department of the museum, but for the creation of scenarios and the conversion of the "source" material to a multimedia application, it was necessary to join forces with the museum curator that was also the museum representative. Despite the use of XML for authoring the content, the full process was very long. At the same time, the technical orientation of the project from the very beginning demanded only some demonstration content to be created, therefore not pushing further than the strictly necessary minimum the content creation of the guide.

Personalization: Personalization features were another point that was not able to be treated in all aspects. All proposed features regarding the low cost delivery and adaptation of multimedia content in several platforms were realized, but it was not possible to advance more, for example, by experimenting with different interfaces or content for different visitor profiles. However, even so, some of the ideas proposed by DANAE, like the session mobility, giving the visitor the possibility to transfer his PDA or TabletPC session on another, larger display, can be considered unique and pioneering in the field.

Evaluation: The author cannot but regret the fact that eventually it was not possible to experiment with the guide in the museum, under real conditions. However the research carried out regarding this phase of the project gave a first classification of evaluation points to be considered for museum guides projects and also a methodological framework which was a source of inspiration for the planning of the evaluation of the Augmented Reality mobile museum guide prototype proposed for the museum of Fine Arts in Rennes (Chapter 4, 5, 6).

2.6 BARRIERS TO OVERCOME AND OPEN ISSUES

If mobile museum guides offer a great potential, why then just few museums are currently able to propose a complete offer with mobile, multimedia and interactive handheld companions? Even if the will to adopt new technologies is taken for granted, museums have to face some issues and barriers which are mainly technological but also human and economical.

2.6.1 HUMAN AND ECONOMICAL BARRIERS

The adoption of new multimedia handheld devices for the guidance of museum visitors brings museums in a position of facing many "human" related issues. The major one is that every museum is unique and special in character; therefore it is quite difficult to come up with a generic technical multimedia solution. Apparently this raises the total cost for the creation and updating of the multimedia guide, which is often one of the main reasons that handheld multimedia guides are not yet omnipresent in museums. As a consequence, a lot of decision-making is requested in such projects: How to implement an application which should absolutely not compete with the current exhibition but supplement it? How to allow a visitor to dig deeply into a subject without losing the narrative of the exhibition? In this sense, a significant amount of work is needed to select relevant contents (text, image, video, speech) from the museum database, to rewrite/reproduce some text or audio contents, to structure them and finally to insert them into an harmonious application that allows to keep the story and the philosophy of the exhibition.

Another very important issue is that the creation of such resources demands an interdisciplinary approach and collaboration that is not always easy to cope with. Certainly, cultural heritage related applications are becoming more and more popular as showcases for many cutting-edge-technology computer applications, but as marked by F. Nicolucci, *"in the hands of technicians, computer graphics applications to material cultural heritage may quickly turn into unfair treatment of information"* (Nicolucci, 2005). Therefore it is a good starting point to gather together people with different abilities, in our case museum curators, museum educators, ergonomists, interaction designers and engineers. However, turning them into a cohesive and efficient team can be a separate challenge (Greene and Sharon, 2000).

On another level, museums have to face economical barriers due to the cost of the deployment of such a system. They need to acquire new devices through buying or rental, store them, maintain and distribute them. The museum IT infrastructure may necessitate interventions among which the stitching of the new application with pre-existing systems (like a web site, stationary PC platform, current tour). Finding a business model is also crucial so as to at least balance the cost of the investment keeping in mind that what is quite advanced today might be rather outdated tomorrow.

To the human barriers one should also mention the reluctance or suspicion that sometimes is provoked by the nature of the intervention. From the museum professionals' point of view, multimedia museum guides must not compete with the actual works of art, neither interfere in the "dialogue" between a museum visitor and a work of art, or distract visitors' attention from it (von

Lehn and Heath, 2003). Though some of these issues are also true for classical audio tours, the “gadget” character of this new media provokes more reactions.

As a museum curator in Tate Modern declared:

“We are obviously not trying to create mini-television programs that people are watching as they go through the galleries.” (Haithman, 2005)

2.6.2 TECHNOLOGICAL BARRIERS

Powerful, multimedia-capable, wirelessly connected and portable, the new generation multimedia handheld devices appear to be the new "grail" for museums in order to assist visitors with the visit and ease the interpretation. Multimodal applications can be tailored to fit specific visitors’ needs, contextual services can be provided dynamically while potentially unlimited content can be delivered to visitors’ terminals.

However, in addition to previously mentioned human and economical issues, museums have to face also some technical issues, mainly linked to content creation, context awareness, geolocalization and content delivery.

Content creation is one of the most important issues. As soon as all elementary media (text, video, audio, pictures) have been selected and gathered in a coherent manner, the application itself needs to be implemented. A manual implementation page by page is only feasible for experiments with limited amount of data. When the content of the future multimedia guide becomes very large, the system should be able to retrieve directly the content from the museum’s database, making it easier to keep it up-to-date. Next to this automatic system, other tools are needed to be able to produce a coherent story (with a 3D avatar for example) and to well gather the different objects and themes into a full-fledged scenario. The scenario itself should be well balanced so that the mobile guide corresponds to visitors' main usage: getting the maximum of information easily, in a minimum amount of time.

As many prerequisite modules for mobile museum guides are strongly linked with the choice of a particular platform we might deduce, that if in the future the market’s evolution allows visitors to use their own terminals, Pocket PCs or mobile phones, the cost could decrease dramatically and a better continuity of usage could be established, combining for example, indoor, outdoor and home usage. Ideally this kind of solution would also allow the museum staff to keep the multimedia guide content up to date, as well as the visitors to communicate with friends inside or outside the museum. Navigation should be as easy as with mobile phones, while the financial contribution for the provided services could take the form of a subscription to the specific service.

Delivery of the content appears to be the next important issue museums need to address. How to deliver the content to the mobile device when the visitor is asking for it? The first obvious solution is to store all content locally into the device which solves at the same time all delivery issues. As we have already seen this solution has been adopted in many experimentations. However, despite the constant increase of the memory capacity of portable devices, the size needed to store all possible scenarios, originating from different contextual parameters, with all audio and video clips, often turns out to be extremely large. The second main drawback in storing the full content locally is that all devices have to be updated as often as the scenario content is updated. To deliver the content through a wireless connection is the second alternative. The current explosion of wireless network (e.g. 3G, GPRS, Wi-Fi, Wi-Max, Bluetooth) offers a set of off-the-shelf solutions that can answer these needs. Wireless technologies and networks tempt also to resolve the very important issue of visitor navigation in the physical space of the museum as well as in its digital application counterpart, which is an issue raised regardless of other important decisions that have to be made. The impact of this decision can be enormous on other candidate modules regarding for example assistance of the visitor in his intellectual and physical way-finding activities, content delivery, communication and interaction. In parallel, the implementation of geolocalization solutions should be in accordance with the general aesthetics of the museum exhibition.

Despite all other remarkable advances in mobile applications geolocalization issues, orientation in indoor spaces remains an open question. Wi-Fi and Bluetooth have been employed in the museum context for geolocalization but are inappropriate for educated guesses about orientation, while RFID and Infrared have also been tested but mostly in a trigger-like manner for delivering or bookmarking appropriate multimedia content [17]. In addition, unlike Wi-Fi and Bluetooth, RFID and Infrared require line-of-sight, difficult to achieve in the sometimes heavily crowded museum spaces. This is why, often enough the interface of mobile museum guides uses visual cues, usually pictures of commented exhibits, to help the visitor to identify artworks and orientate himself in the museum space (Getty, 2005).

2.7 DISCUSSION

This chapter aimed to examine the role and the potential of mobile guides in the museum setting. Mobile museum guides are not just a recent new-age gadget but an interpretation medium alongside with other media used in the museum environment in order to assist museum visitors throughout a visit. As at the same time, they appertain to other IT used in the museum context for purposes ranging from interpretation to documentation and administration, they may serve as a platform onto which a variety of applications can be delivered.

In order to provide a picture of the actual state of the art regarding the use of mobile guides in the museum, nine criteria of classification were discussed. Using the criteria provided allows for the creation of a "profile" of mobile museum guides while it also reveals possible principal functional requirements residing in every mobile museum guide project. The nine criteria are: the media employed, geolocalization capabilities, personalization, continuity of usage of the proposed multimedia application, taking under consideration the social context of the visit, continuity of usage of the proposed application, modules expanded to include the pre- and post-visit phase, inclusion of edutainment activities, delivery-platform ownership and type and local or remote media storage. The discussion of each of these nine criteria combined with illustrative examples from mobile museum guides projects gave also a picture of the current state of the art in this field.

In order to further elucidate the criteria proposed, but also in order to demonstrate other issues that may arise during the full life circle of a mobile museum guide, two mobile museum guides projects in which the author participated, Mobivisit and DANAE, were presented in more detail. Despite the differences in the conception of these two projects regarding the time frame, the involved stakeholders and the type of application eventually created, some resemblances also emerged. In a more abstract level the resemblances can be linked with the topic of human, economical and technological barriers also discussed in this chapter.

In a more specific level, two important issues emerged. The first one is related with the delivery platforms to be used for the delivery of the museum guide's application. Currently, the most common platforms used in related projects are PDAs. Though the Mobivisit project delivered the museum application for the Museum of Fine Arts in Lyon on PDAs, it also explored the possibility, as well as the advantages and disadvantages, of using self-owned terminals, like for example, mobile phones. DANAE also examined this possibility. This is partly due to the fact that the interaction surface of PDAs is small and susceptible to cause problems regarding selection, navigation and manipulation of objects. This was one of the reasons for which DANAE also experimented with other type of platforms, like Tablet PCs.

The second common point of importance was related with the geolocalization issue. As is the case with other museum interpretation media (paper books, audio guides, text), a visitor needs to know how to correlate the pieces of provided information or interpretation material with the museum objects on display. As geolocalization constitutes one of the nine criteria we introduced for the classification of related projects, we also had the possibility to see the different ways this issue can be addressed. Mobivisit used declarative geolocalization, while DANAE used the Wi-Fi technology in order to address this problem. Other methods include the use of Infrared and RFID technologies. All of these methods demonstrate advantages and disadvantages that need to be taken under consideration with regards to the mechanisms provided by each approach in order to assist a visitor in creating correlations between the computer application and the real, surrounding environment. In addition, once the technique of establishing correlations has been mastered by museum visitors, they then also need to learn how to "locate" themselves in the interactive application and how to interact with it.

Under this perspective, the issue of geolocalization seems to be very strongly linked with the issue of interaction. However, geolocalization is not the only influential parameter regarding the complex issue of human computer interaction with mobile museum guides in the museum environment. This is exactly the reason for which the issue of interaction with a mobile device during the museum visit has not been brought up, up till now. In the next chapter, having already familiarized ourselves with the main challenges related with the introduction and use of mobile guides in the museum, we will examine closer the issue of interaction and we will argue that the use of Augmented Reality as a principal component for geolocalization, orientation, and navigation could greatly facilitate interaction both with a mobile museum guide application as well as with the museum objects on display.

CHAPTER 3

INTRODUCING AUGMENTED REALITY FOR MOBILE MULTIMEDIA MUSEUM GUIDES

3.1 INTRODUCTION

In the previous chapter the most influential mobile museum guides projects were presented and a series of criteria for facilitating their classification were introduced and discussed. Our approach demonstrated that each mobile museum guide application is unique and its lifecycle involves a long series of decisions that finally shape the end result.

In this chapter we will examine closer the context of interaction regarding the use of mobile multimedia guides in the museum environment and we will argue that the use of Augmented Reality (AR) could provide an interesting alternative for orientation, navigation and interaction both in the physical (the museum) and the digital (the type of mobile multimedia application examined) context.

The chapter is not intended to provide an exhaustive overview of the numerous technicalities involved in setting up an AR system, a subject that anyhow draws the attention of a constantly exponential number of engineers around the world. It rather aims, first, to examine the existent uses of mobile AR applications and second, to highlight the affinities between AR and "Intelligent" Cultural Heritage applications.

3.2 INTERACTION WITH MOBILE GUIDES IN THE MUSEUM SETTING

Interaction is a key issue and component of any high or low-level computer application. Though the term "interaction" figured already several times in the influential article "Man-Computer Symbiosis" by J. Licklider, published in 1960 (Licklider, 1960), interaction design started to preoccupy the scientific community not earlier than the late '80s (Norman, 1988).

Several years had to pass by before the notion of interaction became popular to the wide public, as illustrated by the 1993 version of the Collins English Language Dictionary. Despite the fact that the verb "interact" is defined as a situation in which "*…two things react together in the same situation, so that they effect each other's development or condition"*, the entry "interactive use of a computer" is still strictly defined as a situation where *"the user and the computer communicate directly with each other via a keyboard and a screen, rather than the user just putting in programs to be run"*. In 2001, Dix et al. (Dix et al., 2001) define interaction as *"a communication between a user and a computer in order to accomplish something…",* and where the "user" can be a single user or a group of users who is *"trying to get the job done using the technology"* and by *"computer"*, *"any technology ranging from the general desktop computer to a large scale computer system, a process control system or an embedded system"*. Similarly, a 2005 definition from Love (Love, 2005) defines mobile human computer interaction (MHCI) as the *"relationship between people, mobile computer systems and applications that they use on a daily basis"*. The importance of treating aspects related with interaction and interaction design is also reflected on recent systematic attempts to employ schools of philosophical thought in order to tackle not only the meaning but also the action-space (or problem-space) of human-computer interaction (HCI). This is, for example, the case with Paul Dourish who -in his book "Where the action is: The foundations of embodied interaction" - examines interaction under the lights of phenomenology (Dourish, 2001). In parallel, the term "Interaction Design" is more and more used as an umbrella-term regrouping several other disciplines susceptible to take part and shape human-computer interaction issues (Preece et al., 2007) (Figure 3.1).

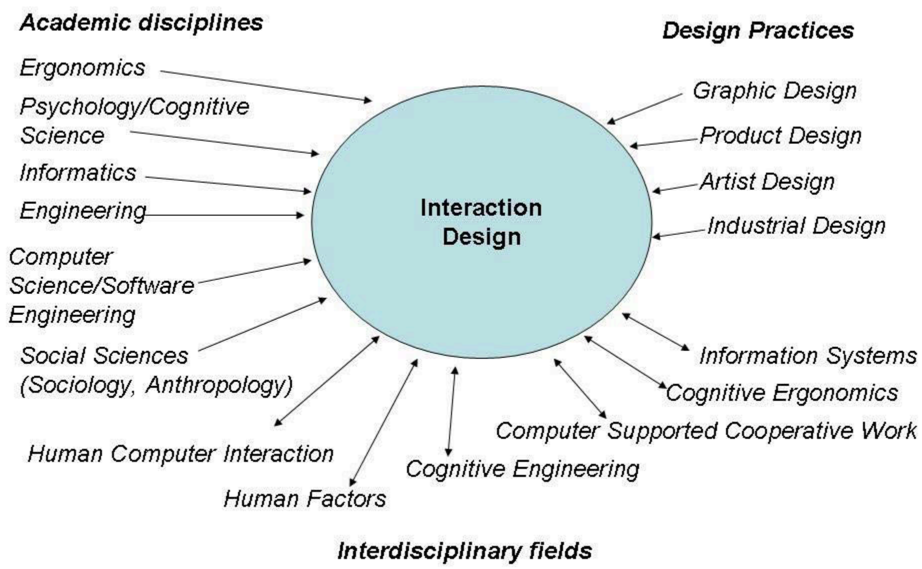


Figure 3.1: Contributing academic disciplines and interdisciplinary fields concerned with interaction design according to (Preece et al., 2007)

From the above mentioned approaches and definitions, it becomes apparent that defining interaction is not a simple task. This is the first reason for which no attempt has been so far made to concretely define what interactive means as to the use of mobile multimedia museum guides. The second reason is that unlike many other HCI examples provided by other application-domains (static or mobile, single or collaborative), interaction in the examined domain appears far more complicated as an issue: the target is not merely a computer user but primarily a museum visitor. Therefore, the use of the interactive application can not be examined only per se, but has to be placed in the broader context of the museum visit, also referred to as the *museum experience* (Falk and Dierking, 1992).

This topic caught the attention of researchers as early as 2001(Aoki et al., 2001). Aoki et al. demonstrated that a museum visitor using a mobile multimedia guide as an interpretation medium is susceptible to interact with one of the three following entities:

1. With the mobile interactive application Interact with the system (1)
2. With the environment, meaning the museum display (2)
3. And, finally, with other visitors or co-visitors (3)

However, the proposed scheme can be enriched and extended if we also examine other possible combinations between these interaction entities. Museum visitors using mobile museum guides are completely capable of interacting simultaneously with more than one entity: for example, and as we already saw in Chapter 2, a collaborative activity proposed by a mobile museum guide, will make the visitors interact between them through the use of the mobile device but also through shared vision of a specific artifact. By examining all possible scenarios, starting from the 3 entities' list proposed by (Aoki et al., 2001), we eventually obtain 7 interaction variations. The museum visitor visiting a museum and making use of a mobile multimedia museum guide might:

1. Interact with the system (1)
2. Interact with the environment (2)
3. Interact with other co-visitors (3)
4. Interact through the mobile system with the environment (1) + (2)
5. Interact through collaboration or shared vision with the environment (3) + (2)
6. Interact through collaboration or shared vision and the use of mobile device with the environment (3) + (1) + (2)
7. Interact through the use of the mobile application with other co-visitors (1) + (3)

(Numbers in parentheses refer to Figure 3.2, where the main interaction entities are shown)

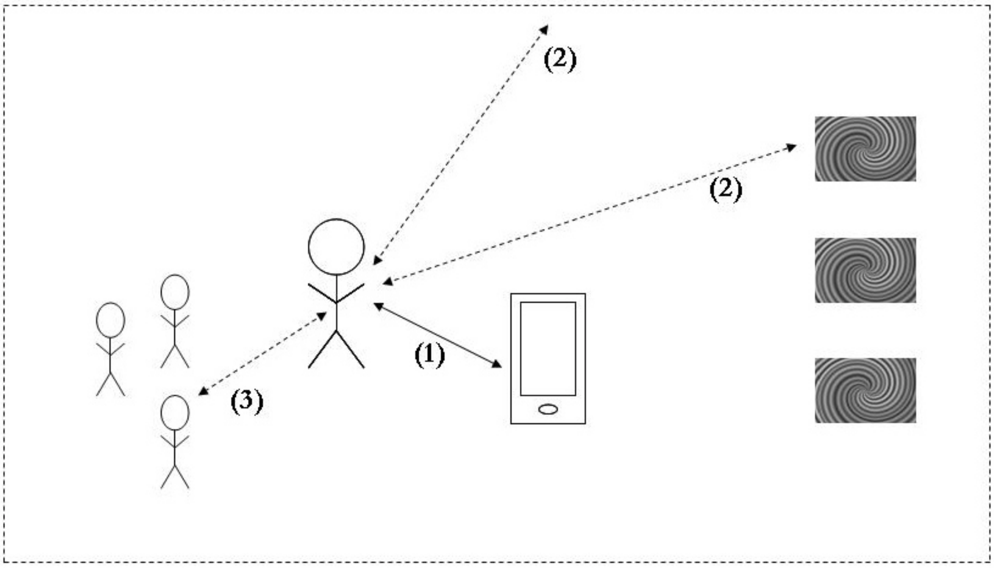


Figure 3.2: Co-existence of interaction entities in the museum setting

In addition, these types of interaction may succeed each other in a quite unpredictable way as the interaction target or entity might switch from one entity to a combination of entities and vice versa. This practically means that the use of a mobile museum guide might involve parallel and synchronous interaction with several entities at the same time, essentially residing either in the physical, surrounding environment or the digital, accompanying multimedia application. For a smooth switching of attention from the physical to the digital and vice versa, the visitor needs to master the links between these two worlds.

There are two important conclusions that can be drawn from the above remarks: The first is that one should be careful whenever discussing interaction regarding the use of mobile museum guides. The type of interaction on focus has to be carefully defined: Is it the interaction solely with the device? Is it the interaction between the device, the visitor and the object? Or is it rather the interaction between other co-visitors while using the device?

The second important remark, is that as a great part of the activity of museum visitors is detected during the task of switching the attention from the device to the environment and vice versa, the creation of straightforward bonds between these two, could facilitate the visiting experience both in the surrounding museum space and in the multimedia application. This aspect has been also examined in section 2.4.2 where the geolocalization issue was introduced and the most important geolocalization methods were described. Therefore, enforcing the bonds between the physical and the digital is not only important for the geolocalization of the visitor and the correlation of the signifier –the multimedia application- and the signified –the museum object on display- but also for the interaction of the visitor with the application, the museum space and other co-visitors.

In the remaining of this chapter we will argue that the introduction of a still emerging technology, Augmented Reality (AR), could greatly contribute to several of the interaction issues examined above. The main promise of AR technologies is to enrich or augment our perception of the real, physical environment by overlaying on it virtual and registered in 3D information. From this point forward we will refer to this mechanism using the term "AR metaphor", in order to differentiate it from the practicalities involved with the implementation of AR applications. In the context of use of mobile museum guides, the introduction of the AR metaphor could be used so as to enable the museum visitor to use the real museum environment as a point of reference, instead of searching a point of reference on a digital, physically non-related with the environment, source of data. In order to accomplish this, the visitors would have to "scan" with their device the environment and wait to see the available information, making appeal to their *intuitive knowledge.*

Intuition is a more and more often used word in interaction design as is the term "affordance", introduced by Donald Norman in 1990 (Norman, 1990). However here, the term intuitive knowledge is borrowed by the well known cognitive psychologist Howard Gardner, whose definition of intuitive could be used as an important argument for the introduction and the adoption of AR technologies. AR is preoccupied with augmenting the real world and the real objects surrounding us with computer generated information. The intuitive knowledge, on the other hand, as defined by Gardner is the considerable amount of knowledge all individuals acquire at the very first years of their life "*by virtue of their interactions with physical objects and with other persons.*" Gardner also includes at this definition *"the initial understanding about the predictable behaviors of objects in the environment…the physical appearance of familiar entities and other universally accessible forms of information."* (Gardner, 1990).

The question that arises therefore is whether the use of AR technologies and the AR metaphor could build on the intuitive knowledge principle, in order to assist individuals to interact in a more intuitive way with computer applications, other people and the environment. The definition of intuitive knowledge by Gardner stresses out that it is principally through physical interaction with objects that we learn during the first years of our life. Consequently, if human-computer interaction gets removed from the computer device and re-integrated back to the real world, it might be easier for museum visitors to navigate in the different information layers provided by the mobile multimedia applications and orientate themselves, both in the museum space and in the application environment. In order to further examine the potential of this approach, a more detailed study of the main AR principles and its current uses will be examined, with a particular focus in applications regarding intelligent cultural heritage.

3.3 DEFINING AUGMENTED REALITY

3.3.1 AR AND THE SWORD OF DAMOCLES

Augmented Reality (AR) is a relatively recent computer science field considered as a subfield of the broader concept of Mixed Reality (MR). The term started to become widely used after 1993, the year in which the ACM Communications magazine dedicated an entire issue to the subject (Cohen, 1993, Mackay, 2000). However, the use of the first head mounted display, created by Ivan Sutherland, dates back in 1968 (Sutherland, 1965, Sutherland, 1968). Because of the limited in processing power hardware, the application displayed only a simple wireframe model overlaid into the real world. The mechanism that was used to hold the Head Mounted Display from the ceiling was the reason for which the application was also described as the sword of Damocles (Kiyokawa, 2007) (Figure 3.3).

There exist several definitions for AR which rather complete than contradict one another.

3.3.2 MILGRAM' S DEFINITION OF AR

In 1994, a year after the special AR ACM Communications issue, Paul Milgram et al. (Milgram et al., 1994), in their approach of classifying Augmented Reality displays, defined what was thereafter to be known as the "Reality - Virtuality Continuum", with the goal to promote the understanding of the interrelations between virtual, mixed and augmented reality environments (Figure 3.4).

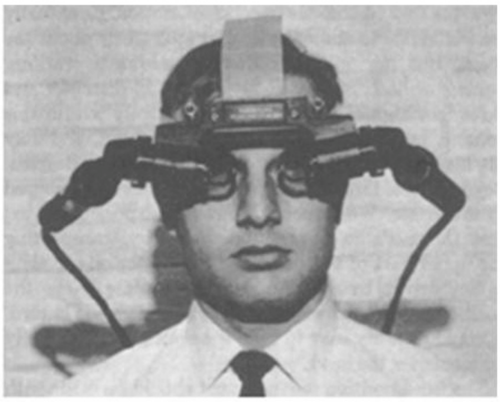


Figure 3.3: The first AR display (to the left, the mechanism used to maintain the display in place)

Mixed Reality environments are characterized by the combination of the real with the virtual. If the real world occupies the left of the continuum, the virtual world stands on the other end. It is however possible to combine elements of the surrounding, real world, in a virtual environment (Augmented Virtuality) as well as to overlay virtual objects in a view of the real world, if the last is observed or seen by means of a video or see-through display (Augmented Reality). It is therefore pertinent to define Mixed Reality (MR) environments as environments in which *"real world and virtual world objects are presented together within a single display, that is, anywhere between the extreme of the Reality - Virtuality continuum"* (ibid, p.283).

Figure 3.4: Milgram's et al. Mixed Reality Continuum (Milgram et al. 1994)

3.3.3 AZUMA'S DEFINITION OF AR

Azuma gave another definition of AR (Azuma, 1997), according to which three requirements have to be fulfilled by AR applications. More in particular, AR applications have to:

- Combine the real and the virtual

- Be interactive in real time

- Be registered in 3D

The first requirement is the fundamental description of AR, the one that precises that AR applications combine the real with the virtual. The second requirement differentiates the definition of Azuma from the definition of Milgram exposed above, as it specifies that the application has to be interactive in real time; this additional element excludes off-line applications, like for example the use of 3D effects in cinematographic productions, from the family of AR applications. The third requirement means that in order to successfully combine in a life-like representation the real with the virtual in real time, an accurate knowledge of the position of the scene and the camera that captures the scene is indispensable. The same condition has to be met when one of these two elements (the scene or the camera) moves.

3.3.4 WENDY MACKAY' S DEFINITION OF AR

Another approach of Augmented Reality which is often enough cited, was proposed by Wendy Mckay in an article published in 1998 (Mackay, 1998). According to this model based on numerous observations relevant to a series of projects, there exist three strategies that help in answering the question "how to augment reality":

- Augment the user, who thus wears or holds a device, in order to obtain information about physical objects

- Augment the physical object, by embedding input, output or computational devices

- Augment the environment surrounding the user and the object with independent devices that collect and provide information.

However, there are several issues that arise from this definition. The first issue is related with the term "physical object" used in all three declarations. Certainly the definition answers the question "how" to augment reality but does not shed light on the question "what" to augment. Is it pertinent to treat the same way all physical objects? For example, does a black and white marker (see section 3.4.2 and fifure 3.6) qualifies as a physical object the same way as a patient's body, augmented with medical imagery so that a doctor can more easily proceed with a surgery or other intervention?

The second issue is related with the second and third strategy proposed by Mckay. The decade that has passed since the publication of this study has seen lot of progress regarding the everyday use of smart devices and appliances. We now talk about ambient intelligence, smart devices or ubiquitous computing. The progress on the field is so important that most of the times it is now possible to draw the line between AR applications and smart devices or ambient intelligence applications.

3.3.5 A SUPPLEMENTARY DEFINITION OF AR

An additional classification scheme for AR applications can be provided if we attempt to define the nature of the physical object as well as its relation with its virtual counterpart or augmentation. In this case, instead of attempting to answer the "how" of AR applications, we focus on the "what", or the real nature of the object to augment. This approach might help better define, the "problem-space" (or action-space), which should ideally proceed the phase of applying strategies (Preece et al., 2007).

The new classification scheme that we propose builds on the following observation. AR applications tend to augment two different types of objects. The augmentation will either augment an existing physical object (like for example a painting, a patient's body, an urban setting etc), or compensate for the lack of an object, as for example is the case with AR applications using markers to render or help visualize physically non existing objects. The application of this criterion results in two main categories of AR applications. Starting from the latter, an AR application would either:

A) Replace/render a physically non existing object. Ideally in this case, the interaction should give the user the impression of interaction with a real object.

Or

B) Visually supplement an existing physical object.

Additionally, regarding the 2nd case, we propose an additional criterion which will result in the definition of three subcategories. This second criterion is provided by the interaction possibilities proposed by the designer of the system. More in particular:

B1) the augmentation can be manipulated through interaction with the physical object: The user will interact with the real, manipulating the virtual. An example of this subcategory is provided by the AR paper projects discussed by McKay. The user interacts with the real paper. His actions are also affecting the virtual counterpart of the application.

B2) the physical object can be manipulated through interaction with the augmentation: The user will interact with the virtual, manipulating the real. A good example regarding this category is provided by medical AR applications. The doctor manipulates the virtual (the medical imagery), so as to interact with the real (the patient's body).

B3) only the augmentation and not the real object can be manipulated: There exist cases where it is not possible or desirable to change the state of the real object augmented. In this case, only the virtual part of the application (the augmentation), can be manipulated. In this category we can include the AR mobile museum guide prototype, as the user can only interact with the augmentations, and not with the real object.

Finally, as to the new classification scheme that we propose, it is important to note that cases B1 and B2 can be combined in one single AR application.

3.3.6 DISAMBIGUITIES CONCERNING THE USE OF THE TERM AR

Any researcher having approached the issue of use of mobile guides in the museum setting or simply just the issue of AR, might have noticed that sometimes there is a disambiguity in the use of the term "augmented". As the initial meaning of the verb "to augment" is to render something greater, in size, extent, or quantity, some researchers employ the word augmentation with this meaning in order to describe computer systems that add a new dimension to conventional activities such as a museum visit (Spasojevic and Kindberg, 2001, Ferris et al. 2004). Disambiguity can also result from the fact that the term "augmented" can also be used for audio (Wakkary et al., 2004) or haptic augmentations (Bowman et al., 2005), cases that will not be examined in our state of the art focusing on Mobile AR applications and Cultural Heritage related AR applications.

3.4 APPLICATION REQUIREMENTS FOR MOBILE AR SYSTEMS

3.4.1 PRINCIPAL COMPONENTS OF MOBILE AR SYSTEMS

From the definitions of Milgram (Milgram et al. 1994), Azuma (Azuma, 1993) and Mckay (Mackay, 1998), one can induce some of the principal components of mobile, AR systems (Figure 3.5). Wearable or portable input (camera) and interaction devices to interact with the augmented world are needed, displays in order to incorporate the virtual data in the physical world or object, data storage and access and of course a computational platform for the coordination of the full chain, including the tracking and the 3D registration of the real scene. Wireless networks could facilitate the data access if the last is stored on a remote server (Damala, 2007a).

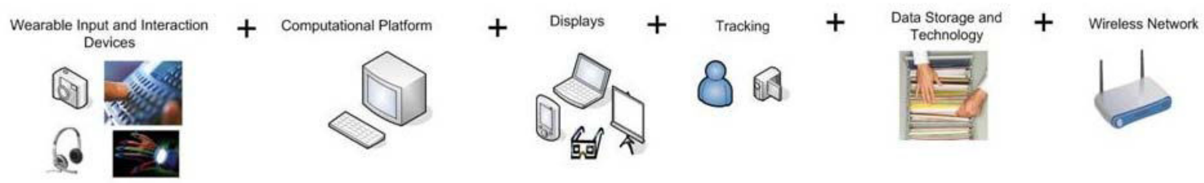


Figure 3.5: Basic components of mobile AR systems

3.4.2 TRACKING AND REGISTRATION

Two mandatory requirements for the implementation of viable and robust AR applications need further clarification because they are susceptible to confuse AR projects stakeholders who do not have a technical background, as is the case with cultural heritage related applications. In any AR application, a tracking mechanism is needed so as to constantly know the position and the angle by which the physical object is viewed by the camera, in order to register the virtual object with which it will be augmented with respect to the real world. This feature of AR applications is very important because unlike Virtual Reality applications, where the user is totally immersed in a virtual environment, the human vision system can difficultly tolerate even small registration errors present in AR systems (Azuma, 1993).

Tracking can be further decomposed into two main steps: Image processing, in order to extract some information from the image, and pose estimation itself. The most usual way to achieve this is by computer vision. Vision-based tracking can occur either through the use of what the AR community calls fiducials or markers (Figure 3.6) or by using natural features. The first approach is the easiest to implement. The markers are added to the physical world, are seen by the camera and detected by the AR software that will decide where to place the augmentation. The most comprehensible and easy to use package is ARToolkit (ARTOOLKIT) while recently another system, ARTag (ARTag), has been proposed. The second approach is based on the detection of natural features and is considerably harder to achieve, depending on the context in which an application will be used. However, in both cases, if an object is totally or partially occluded, the augmentation might disappear. For this reason other possible methods could be used alone or in combination, like mechanical trackers, magnetic trackers, ultrasonic trackers and inertial trackers (Hollerer, 2004). Finally it should be also noted that the choice of an appropriate method also depends on the initial requirements set, as the level of accuracy of the final rendering is not the same for all types of AR applications. For example an AR application for use in an archeological site does not need the same level of accuracy as a medical AR application, destined to allow a doctor to operate a remote patient.

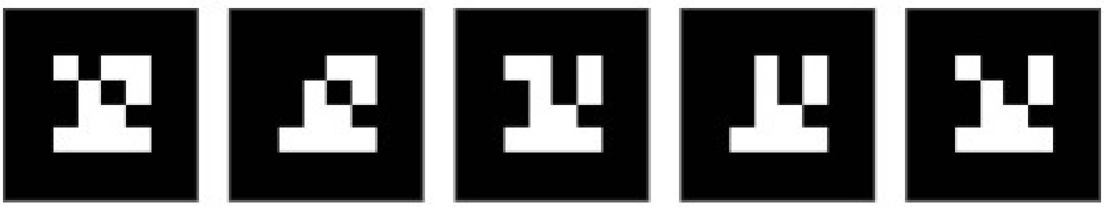


Figure 3.6: Examples of fiducials/markers used for pose estimation in AR applications

3.4.3 PANORAMA OF EXISTING AND FUTURE AR DISPLAYS

The issue of candidate platforms for mobile AR applications is of central importance not only for the level of immersion in the AR applications but also for the possible ways of interaction with the proposed system (this issue is also discussed in chapter 5, section 5.3). The first experimentations in mobile AR were based on custom configurations that resulted not only in expensive but also heavy and bulky equipment usually carried by the user, in addition to wearing a head mounted display. Such configurations could difficultly break in the museum premises, if not for purely research purposes and will not be examined here, except if related with cultural heritage applications (see section 3.5.2). The rest of this section sets out to explore other mobile candidate platforms that are or will be available in the near future and could be appropriate for use in the museum. Six types of platforms have been identified in total:

1. Pocket PCs or PDAs

As already examined in section 2.3.8, Pocket PCs or PDAs have been often enough be used in the museum setting for the delivery of interactive multimedia applications. The main disadvantage of PDAs is their small screen of approximately 2.5 x 3 to 2.5 x 6 inches. At the same time fears are expressed that in the near future with the widespread adoption of an all-in-one phone, PDAs will become obsolete. On the positive sides, they are more affordable than other categories of material and extremely lightweight and easy to carry. Regarding AR applications, Pocket PCs or PDAs should be equipped with a camera, in order to be considered as candidate platforms.

2. Cell Phones and Smart Phones

The actual offer in the market regarding cell phones is huge, unlike the reserved initial predictions (Harper, 2003). The current trend wants cell phones to progressively integrate many other characteristics, like cameras, a sine-qua-non of all AR applications, and of course networking capabilities. However their processing power is lower than the one found in PDAs and UMPCs. Nokia's project MARA explored the use of camera equipped mobile devices as platforms for sensor-based, video see-through mobile augmented reality in an urban setting (Schmeil and Broll, 2006). France Telecom Research and Development division in UK and France have also experimented with navigation in an urban environment using cell phones (West, 2006). Finally, recently audio and multimedia guides' companies have also started examining the delivery of exhibit related multimedia content on I-Phones (http://www.sycomore-france.com/)

3. UMPCs or Ultra Mobile PCs and Tablet PCs

UMPCs are dotted with much larger screens and processing power that makes them simply excel over PDAs, but the disadvantage is that they are considerably more expensive and much heavier than them. Two specific types of UMPCs are closer examined in section 4.2.1, as this was the platform that was finally selected for the experimentations in the museum of Fine Arts in Rennes. To our knowledge this is the 1st type that a museum guide is delivered on UMPCs.

4. Handheld Game Devices

Devices of the type of Nintendo DS and Sony's PSP are designed for playing using one or both hands making them convenient as candidate platforms for the museum visit. As with PDAs, for AR applications, a camera should by all means be integrated in the system for an AR system to function. Nintendo recently announced that a team is working on the creation of a special Nintendo edition, equipped with an integrated camera, which could be used as a mobile multimedia guide in a theme park and other tourist attractions. Discussions and a pilot project have already begun, in co-operation with Disneyland and if things go well the application might be released in 2009 (Figure 3.7). In the case of platforms like Nintendo or Sony PSP, a serious factor to take under consideration is the "closed" architecture of such systems.

Figure 3.7: Pilot application running on Nintendo DS, Walt Disney World Resort, USA (illustration extracted by Joel, 2008)

5. AR Goggles

AR goggles are a much lighter version of head mounted displays. In both cases and as with head mounted displays (Kiyokawa, 2007), two categories of AR goggles can be distinguished: Optical see-through displays and video see-through displays. Their main difference is that optical see-through displays allow the overlaying of synthetic imagery over what the user sees through the see-through glasses using a combiner (Figure 3.8a, 3.9b, 3.9e). Video see-through displays, like Sony Glasstron (Figure 3.8b), present to the user the captured version of the real surrounding environment, combined with the virtual objects, implying that when there is a system failure the peripheral vision of the user is lost (Kiyokawa, 2007). Their full potential could be unleashed in the future, when they would be able to connect, ideally wirelessly, with small, easy to carry devices like cell phones, PDAs etc.

6. The future of AR displays

Finally, a more futuristic scenario that has nevertheless made its debut in 2008 is concerning the implementation of a see-through display that will have the form of a contact lens (Figure 3.9f) and will provide “first person shooter-type video game”. The University of Washington and the Pentagon’s science and technology division DARPA are working on this project and believe that this special type of contact lens will be available in three to five years time (Greene, 2008, Shactman, 2008). According to the information released, the lens could be used not only as a display but also as a sensor monitoring the body’s function and alert the user if any sign of malfunction appeared.

There have also been proposals for displays that at least for the time being remain only design projects but are nevertheless very inspiring. For example, Mac Funamizu, a Japanese web and graphic designer, created some mockups of his dreamed or ideal AR display (Figure 3.9d); according to his words: *“This is what I wish the Internet search will be able to do with a mobile device in the near future. Touch screen, built in camera, scanner, Wi-Fi, google map (hopefully google earth), google search, image search… all in one device. Like this way, when you can see a building through it, it gives you the image search result right on the spot.”* (Funamizu, 2008).

Figure 3.8a-3.8b: A. Mockup of lightweight optical display (Low, October 27th, 2008) and B. The Sony Glasstron video see-through display (CNN, February 2, 2000)

Another interesting prototype, directly inspired by the common magnifying (or magic) lens AR metaphor (Billinghurst, 2004, Brown and Hua, 2006), was proposed by Ryan Olson. The display has the form of a real magnifying glass and is equipped with a built-in camera with up and down tilt, a multi-direction thumb control for navigation, a headphone jack, and a USB port for flash drives, data synchronization and charging (Figure 3.9a). The handle of the lens can be detached and used as a stylus (Olson, 2007).

In conclusion, despite the creativity of both designers and engineers, up till today, no universal, mass market platform for the delivery of mobile AR applications exists. This has a great impact on AR HCI issues, as we also saw in this small review of candidate AR platforms: The way and method of delivering the augmentation to the final user is also capital for the interaction with the mobile AR system. It is not by hazard that the definition of general HCI principles is not an easy task for mobile AR applications. This issue shall be further examined in the Methodology chapter, section 5.3.

Figure 3.9a-3.9f: Future AR displays. A. An AR magnifying lens prototype (Greene 2008), B. "microvision" augmented car windshield (Microvision, October 27th, 2008), C. "A-RAGE" outdoor AR gaming prototype (A-Rage.Com, October 27th, 2008), D. Funamizu's mockup of the ultimate AR display(Funamizu, October 277th, 2008), E. "microvision" eyewear for AR (Microvision, October 27th, 2008) and F. the AR contact lens under deployment at the University of Washington.

3.5 MOBILE AR APPLICATIONS

3.5.1 INTRODUCTION

The very essence of the potential of AR, supplementing the real rather than only acting as a substitute, has opened up new possibilities in human computer interaction. Though, it is not in the scope of this study to provide an in depth coverage of all types of Augmented Reality applications, we shall briefly examine some main categories, in order to form an idea of the full spectrum of the fields in which AR could be employed, before examining more in depth the affinities between AR and "intelligent" cultural heritage applications. Already in his article "A Survey of Augmented Reality", Azuma (Azuma, 1997) defined six classes of applications for employing AR: medical visualization, maintenance and repair, annotation, robot path planning, entertainment and military navigation and targeting.

3.5.2 A SPECTRUM OF POSSIBLE APPLICATIONS FOR AR SYSTEMS

There exists a broad spectrum of domains in which mobile AR applications could find meaningful uses. For example, the piloting training curriculum has been using long time now AR to assist trainees and instructors in the visualization of landscapes and in the simulation of situations demanding a prompt response from a pilot. Military training has been also heavily depending on AR applications and it should be noted that in this specific context of use, AR applications are way ahead in comparison with civilian uses and case studies (Hollerer, 2004).

The use of AR systems could also make benefit the industrial chain of productions or operation of assembly and maintenance. Boeing has been one of the first companies to experiment with an AR system conceived to assist in the construction chain (Hollerer, 2004) and recently a major European automobile constructor also explored the same possibility for the repair and maintenance of cars (Sandor and Klinker, 2005). The engineer wears a pair of AR glasses and sees on the vehicle the exact location on which he has to intervene, following well defined steps. Each time he performs a step and wants to advance further he commands the system using his voice. Everyday-life tasks involving machines could also be a field for meaningful mobile AR applications. For example, an employee having to deal with a paper jam on a printer could use a mobile AR application to obtain assistance instead of looking up a manual.

Medicine is another domain that could benefit by fixed and mobile AR applications. For example a doctor could be assisted by the overlay of virtual information on a patient's body to visualize elements that are invisible with naked eye or to perform high precision tasks (e.g. perform a biopsy on a very small tumor).

Another field for which experiments have already taken place is this of urban planning, architecture and interior design (Binder et al., 2004). The use of AR could not only assist the domain professionals in planning and visualizing their interventions but also facilitate their communication and collaboration with their clients, who might have a difficulty visualizing in three dimensions the proposed solution (Maquil et al., 2007).

Another everyday task on which AR can be applied is tourism, navigation and way finding (Borntrager et al., 2003). During the last years the market has been witnessing a massive intrusion of initially PDA based GPS navigation systems, now also available for mobile phones. In parallel, companies are also exploring the potential of integrated AR displays in vehicles, as we can see in figure 3.8b, where an AR system is integrated on a car's windshield (Microvision, October 27th, 2008).

Apart from education (Balog, 2007, Shelton, 2002), for which some examples of AR applications will be provided later on, as they are directly related with the informal learning character of the museum visit, AR could also revolutionize the game industry by proposing collaborative games that merge the real scenery with the virtual and therefore by adding a new dimension in playing and experience-sharing. For example, "Human Pacman" allows game players play Pacman in a role-playing mode, where some of the players are the ghosts and some others the pacmen, while the cookies to be eaten are incorporated also in the environment (Cheok et al., 2004). In a category combining entertainment and education or edutainment as more and more employed, Ambient Wood proposed to children, equipped with PDAs, to discover a spatial annotations augmented forest and learn in a playful way some of the characteristics of this ecosystem (Rogers et al., 2004). An interesting configuration of gaming AR equipment (A-Rage.Com, October 27th, 2008) was proposed by the Australian a-rage project (A-Rage.Com, October 27th, 2008). However, as AR and MR applications can be delimited only by the imagination, more peculiar applications are also often enough proposed. An illustrative example is provided by the project poultry Internet, where a user is able to interact from a distance, with a chicken wearing a special AR jacket, by manipulating a doll replica of the real animal (Teh et al., 2006).

More unfortunately, as AR is a relatively new discipline, sometimes the arguments used to promote the use of the technology, are not always very well thought. In one of the largest in the domain of intelligent cultural heritage annual conferences, held in 2004 (and in which the author was present), a member of a team presenting an AR system for the rendering of museum objects, not only wrote but also told the public that the proposed AR system could be used in a museum to allow handicapped visitors to virtually see museum objects physically exposed in the museum galleries. Naturally, many participants later discussed in corridors that the solution in this case is not to invest on cutting-edge AR systems but rather to invest on building the minimum necessary infrastructure so that handicapped visitors have access to the museum for real.

3.6 AUGMENTED REALITY APPLICATIONS AND CULTURAL HERITAGE

3.6.1 INTRODUCTION

Cultural heritage related AR applications may be considered to form a distinct category of AR applications, partly belonging to tourism and navigation systems and partly to the category of educational AR applications. The literature review of all relevant projects resulted in five categories that will be examined in this section: Fixed Position Indoor or Outdoor AR applications, Wearable Indoor or Outdoor AR applications, Indoor Mixed-AR Installations, Mobile AR applications, while AR applications that replace or render physically non-existing objects, will be examined in a separate section.

3.6.2 FIXED POSITION INDOOR OR OUTDOOR AR INSTALLATIONS

Augmented Reality visualizations can provide extremely meaningful insights when applied in archaeological or historical parks or museums, not only for the specialist or initiated visitor but also for the non-specialist or first time visitor who has difficulties in imagining how a site could initially have looked like. Fixed AR applications have been tested at the Ename centre in Belgium (Owen et al., 2005). The system superimposes onto the real scene 3D reconstructions of the monument as it once was, and displays the result on a visualization device (Figure 3.10b). The same principle is applied in a commercialized system installed in historical and archeological sites in Portugal, Brazil and China (Thomasson, 2006). The term employed for this product is "Virtual Sightseeing" but in essence the approach is clearly based on Augmented Reality both in terms of metaphor and technology. A booth is placed at a certain distance from an archeological monument. The user is able to rotate the booth around its position like he would do with a telescope and visualize on the display of the kiosk the monument with augmentations that give a picture of how the monument would have once been like (Figure 3.10c).

In an indoor environment, Bimber et al. presented the Virtual Showcase, an AR fixed display, conceived to allow tracked museum visitors to view stereoscopic images of augmented exhibits (Bimber et al., 2003). The initial scenario was inspired by paleontology and aimed to show visitors the steps undertaken by paleontologists to reconstruct with muscles, soft tissues and bones the skull of a dinosaur. An email communication with one of the authors confirmed that the skull used during this first demonstration was not an original. However in a more recent publication concerning the second implementation, which resulted in a permanent installation of the mechanism in the Deutsches Museum in Bonn, Wendler and Fröhlich note that "the showcase contains a real turntable with real artifacts on top" (Wendler and Frohlich, 2005). The visitors put on stereo glasses and focus on the stereoscopic presentation that they control through a handle that makes the display rotate (Figure 3.10a).

Figure 3.10a-3.10c: A. The virtual showcase, B. Ename 974 project and C. y-dreams AR outdoor kiosk (see section 3.6.2 for the sources of the pictures)

However, regarding the museum environment, the disadvantage of this approach is that it is invasive in character. In addition, as is also the case with multimedia kiosks installed in museums, this solution demands from the visitors to move from the original museum display to the multimedia installation in order to consult the provided interpretation material.

3.6.3 WEARABLE AUGMENTED REALITY SYSTEMS

Another distinct category of Augmented Reality applications is this of Wearable Augmented Reality applications. As in contrast with mobile AR applications presented in section 3.3.5, the visitor has to "wear" and not just hold the necessary equipment. This is certainly a disadvantage, as in most cases the equipment is heavy, bulky and fragile though it allows the use of powerful laptop based processors and head mounted displays.

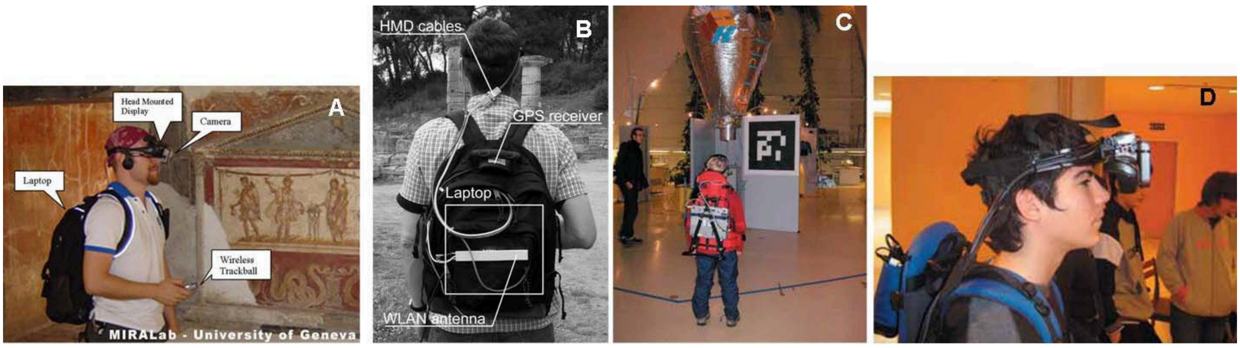


Figure 3.11a-3.11d: Wearable AR systems applied in the domain of Cultural Heritage. Illustrations extracted from (Anastopoulou and Sotiriou, 2005, Gleue and Daehne, 2001)

One of the first systems of this type was the ARCHAEOGUIDE project which was launched in 2000 (Gleue and Daehne, 2001, (Vlahakis et al., 2004, Vlahakis et al., 2005, Vlahakis et al., 2003). The system was conceived for the site of Olympia in Greece and lasted two and a half years. The goal was the implementation of a system that would assist the visitors of the archeological site in better understanding how the site would have once looked like using AR technologies. Despite the fact that the concept ARCHAEOGUIDE set to explore was pioneering, the proposed configuration of the equipment the visitor had to wear was quite compromising (Figure 3.11b, Figure 3.12). The system, that demanded from the visitor to wear a head mounted display and carry the main computational unit in a backpack, was reported by visitors to be heavy and cumbersome (Vlahakis et al., 2002).

Figure 3.12: The Archeoguide project, non-augmented and augmented view of the Hera temple in Olympia (illustrations extracted by (Vlahakis et al., 2002))

The LIFEPLUS (Innovative Revival of Life in Ancient Frescoes and Creation of Immersive Narrative Spaces Featuring Real Scenes with Behaviored Virtual Fauna and Flora) project (Papagiannakis et al., 2002) can be considered to be the successor of ARCHEOGUIDE not only because both projects explored the potential of AR techniques used in archeological sites, but also because several of the ARCHEOGUIDE project stakeholders also participated in the LIFEPLUS project, initiated in 2002 and completed in 2004.

The main difference between the two projects was that instead of mainly focusing on ancient buildings and architecture, LIFEPLUS sought to populate with virtual humans the archaeological site of Pompeii so as to assist visitors in visualizing aspects of the Roman's everyday life (Figure 3.13). As in ARCHEOGUIDE, the captured video of the real archeological site serves as a canvas onto which people, animals and plants of the roman era co-exist and interact with each other. The equipment is basically the same as in ARCHEOGUIDE: the visitor is equipped with mobile computing equipment carried on a backpack and wears a see-through Head-Mounted-Display

(HMD) and an earphone (Figure 3.11a). A tracking system determines their location within the site and audio-visual information is presented to the visitors superimposed on their current view of the site. In order to render the visualizations more realistic, extensive work was undertaken for the rendering and simulation of the 3D humans.

Another related project, also seeking to explore the potential of AR, but this time in an indoor environment, was the "ecsite/connect" project (Designing the Classroom of Tomorrow by using Advanced Technologies to connect formal and informal learning environments) (Anastopoulou and Sotiriou, 2005).

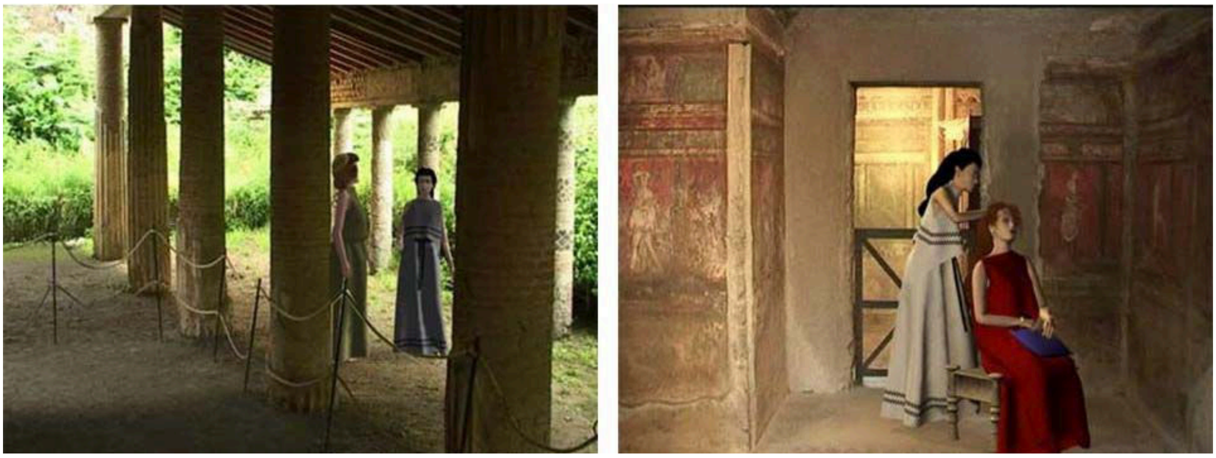


Figure 3.13: Virtual humans acting in Pompeii archeological site, LIFEPLUS project (images source: Miralab-Geneva University)

The project used AR technologies in order to assist schoolchildren better comprehend several physical phenomena, planning for activities that would occur both in the formal classroom learning environment and in the informal museum learning environment. The experiments took place in four countries and involved the study of interactive exhibits. The first exhibit, "Why do planes fly", came from the Explore-At-Bristol space, in the UK (Figure 3.14c). It aimed to demonstrate the forces acting on airplane wings and was designed for children between 10-16 years old. The 2nd exhibit was the "Airtrack", coming from the Museum of Science and Technology of the University of Athens. The exhibit demonstrated some laws of motion, particularly principles relative with the phenomenon of friction and was destined to children aged 15-16 years. Its title was "What stops things from moving?" (Figure 3.14b). The 3rd exhibit was named "What keeps a balloon moving up and down?" and was hosted in the Heureka centre, Vantaa, Finland (Figure 3.14d). The target group of this intervention were children between 11-13 years old that would explore this way the relations between pressure, volume and temperature. Finally the 4th exhibit, the "Biotube", came from the Xperiment Huset, Växjö, Sweden and aimed to teach students several aspects of photosynthesis (Figure 3.14a). The elements appearing on the display the students wore were manipulated with a wireless mouse.

Despite the burden of the proposed AR equipment, the “connect” project set out to explore several innovative ideas like the creation of links between formal and informal learning environments and the definition of a course of action for the pre and post-visit phase. In addition the proposed approach was evaluated in real conditions, involving real users (Sotiriou et al., 2006). Regarding the museum environment however, the use of indiscrete, large markers can be considered as being rather invasive in character.

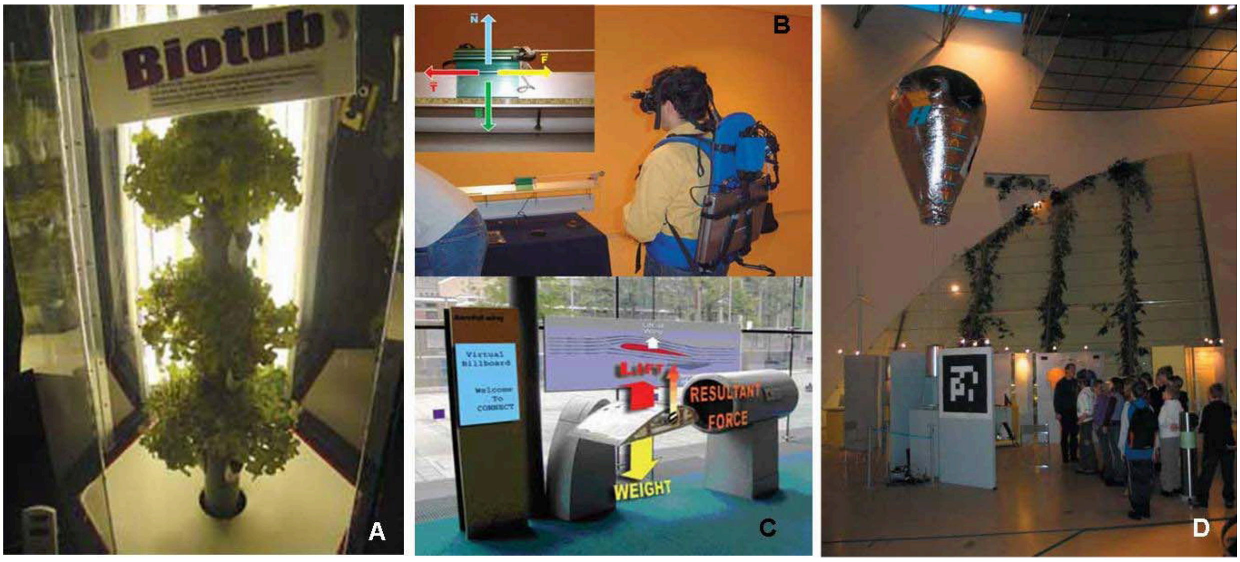


Figure 3.14a-3.14d: The four exhibits used in connect project (Anastopoulou and Sotiriou, 2005)

3.6.4 MIXED AND AR INSTALLATIONS

This category is examined separately from the first category “Fixed Position AR applications” on purpose, as it includes systems that borrow both from AR and MR applications are multimodal and combine the synchronous use of more than one displays or interaction devices.

VITA (Visual Interaction Tool for Archaeology) is a Mixed Reality (MR) system for the offline visualization of an archeological dig (Benko et al., 2004). The data gathered for the project came from the archeological excavations of Stanford University in Monte Polizzo in Sicily, using various documentation methods such as 3D laser scanning, video sequences, panoramic images and high resolution images of artifacts discovered during the excavation. The goal was to collect diverse material for an accurate off-line and off-site visualization of the architectural remains, the digs (pits), and the objects excavated. For the visualization the system used a tracked, head-worn, see-through display and for the interaction with the virtual objects the users could use either tracked gloves or a special table surface on which their gestures could be detected. The system was then tested not only with archeologists but also with archeology students who reported that the system helped them to visualize the archeological site and to easily locate the distribution of the excavated objects in the excavation area (Figure 3.15).

A similar experience, but this time using only a table surface and a normal brush as interaction tool, was created for the Seattle Art Museum as part of the Sichuan China artifact exhibit in collaboration with the HITLab in Washington. Though according to the webpage of the project (http://www.hitl.washington.edu/research/sichuan/), more than 25 000 participated in this experience, it seems that unfortunately no publication on the project is available.

Figure 3.15: VITA system: Real view of the excavated site and its MR lab reconstruction (Benko et al., 2004)

Another installation based on the concept and techniques of AR was implemented and tested with real museum visitors in the frame of the "One Rock" project (Reeves, 2004, Reeves et al., 2005). The AR installation made part of an exhibition regarding a large rock in Morecambe bay, England and had the form of a Telescope, allowing visitors to examine one by one, hundreds of bottles placed on a metal structure a bit further, the "Incubator", which contained several specimens of microscopic sea life elements collected on site.

3.6.5 AR REPLACING/SUBSTITUTING REAL OBJECTS

According to the definition we proposed in section 3.2.5, there also exists another group of distinct AR applications. In this case the AR installation or solution proposed does not supplement or augment a physically existing cultural object but is rather used as a substitute or replacement, either because the real object is not impossible to be used or because the real object is not desirable to be augmented. This kind of solutions can be usually more low-cost and present the advantage that the object to be augmented stays intact.

An example of the second case is provided by the ARCO project (Petridis et al., 2005, Sylaiou et al., 2005, Walczak et al., 2005, Walczak and Wojciechowski, 2005, White et al., 2003, Wojciechowski et al., 2004). Among the goals of the project was the creation of a system that would allow museum curators to create exhibitions of objects that are not displayed in the museum exhibition but stored in a storage room. This is a realistic case study as the large majority of museums around the world cannot afford to have on public display all of the objects they possess. This kind of system could allow remote students or researchers to examine 3D replicas of an object without having to be displaced, or school children to have the impression that they hold and manipulate valuable and usually very fragile ancient objects. This way, museums could be assisted in the valorization of all the richness of their collections. Another project of this type is the "virtuoso" project, aiming to assist the teaching of history of art, either in the museum or the school premises. Using the technique of markers, Mr .Virtuoso proposes to young students to use their PDAs, in order to visualize art objects and arrange them with the correct chronological order (Wagner et al., 2006).

Figure 3.16: AR applications used as substitutes of real objects. Illustrations extracted from (Liu et al., 2007, Woods et al., 2004)

Five other innovative applications developed for exhibitions and science centers are presented by Woods et al. (Liu et al., 2007, Woods et al., 2004). The SOLAR system, created for the TeManawa science center in New Zealand, invites the visitor to try to place all planets around the sun in their correct location. When this is done the planets begin to orbit around the sun (Figure 3.16a-3.16b). What is very interesting in this example is that the images used for the final rendering of the planets are based on accurate satellite imagery, allowing visitors to compare the surface of each planet. The visitors can play two by two holding a visor that allows them to see the planets, as shown in Figure 3.16b. This group of scientists has also experimented with several prototypes of AR books (Grasset et Al., 2007a). These can be read as any other normal book, but the use of a similar AR visor allows virtual characters to jump out of the book and act the story. Another group of researchers also experimented with the use of AR for teaching sciences, but this time in a more formal class environment (Figure 3.16c) (Liu et al., 2007, Woods et al., 2004). The obvious advantage with this kind of approach in teaching is that students can progress advancing at their own pace. Finally a more recent example comes from the Futuroscope in France and –equally using the marker technique- allows users not only to visualize how the animals of the future could look like but also see how these animals would interact between them if they were met (Futuroscope, 2008). The user can group the markers representing the animals and see in 3D how they would behave. From the above mentioned experiences, the Black Book and the Animals of the Future just mentioned can be also downloaded and executed at home, using a standard web cam.

3.6.6 AUGMENTED REALITY ON MOBILE SYSTEMS

As the proliferation of mobile devices and services does not cease to demonstrate a dynamic that influences most aspects of our everyday life, it is very natural that several groups of researchers around the world join forces in order to create AR applications that will be low cost and delivered to users self-owned mobile devices, such as cell phones, smart phones or PDAs (Wagner, 2007). In section 3.4.3 the Nokia MARA project was briefly presented as well as similar experimentations carried out in France Telecom RD division. In both cases the projects envisioned to augment outdoor environments with annotations revealing the nature of the seen objects, for example the opening hours of a shop or other relative information.

In the domain of cultural heritage, these kind of approaches are still rare, but have nevertheless began. The first example that can be provided is strongly related with the ARCHEOGUIDE project discussed above, in section 3.5.2. After trying out the initial configuration and receiving as feedback from visitors but also archeologists that the system is too heavy and bulky to be considered for use, PDAs and Tablet PCs were used, resulting in two brand new products one of the stakeholders commercialized, for use in indoor and outdoor spaces (Vlahakis et al., 2005).

The Bauhaus University AR group in Weimar, after releasing as a commercial solution the studierstube tracker, an AR computer vision library destined to mobile devices and cell phones in particular, has started to explore the potential of use of cell phones in the museum for guidance using AR (Bruns et al., 2007). However so far only results concerning the system performance have been reported and no user-centered study is known to have been released.

Finally, a group in Japan has been moving towards partially realizing the scenario proposed by the Dinohunter project discussed in section 2.4.7. They used a PDA in order to allow visitors at the National Science Museum in Tokyo, Japan augment dinosaurs' skeletons and visualize how they might have looked like (Kondo et al., 2007).

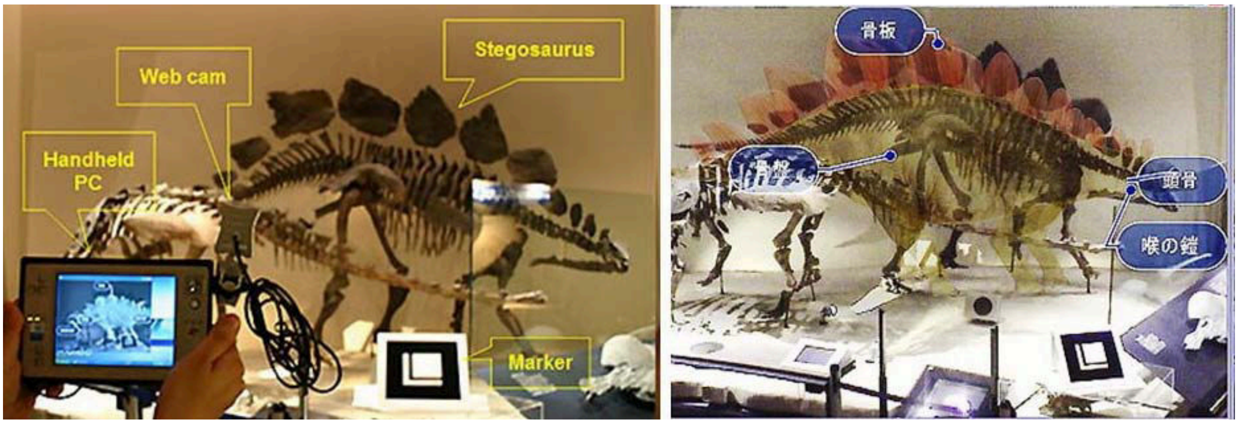


Figure 3.17: The AR guide implemented for the Museum of Natural History, Tokyo, Japan (Kondo et al., 2007).

3.6.7 CONCLUSIONS

All of the examples mentioned above demonstrate that AR can indeed have very meaningful applications regarding the interpretation of Cultural Heritage as it allows for the invisible to be seen, in a playful way that has been reported to attract visitors of all ages and backgrounds (Woods et al., 2004). However, fixed-position AR installations that have already been used in outside environments -like archeological and historical sites- are invasive in character and static, allowing a one to one relationship with the augmented objects. On the positive sides, their configuration allows robust and precise AR visualizations, as they make use of hidden, powerful processing units.

Wearable AR systems, composed by a processing unit, usually worn by the visitor or the user together with a head mounted display, also allow rich AR visualizations to be created but are usually custom-made, heavy and bulky and -often enough- fragile. It goes without saying that this kind of equipment could not be used in a museum if not for purely research purposes. If, in addition, the system requires the use of large and indiscrete markers, as was the case with the "ecsite/connect" project, then things get even more complicated.

Mixed reality installations on the other hand can be considered more as part of an exhibition and less as an interpretation medium for a particular exhibit. It should nevertheless be stressed out that this kind of installations have a very good potential and could add a lot to the comprehension of the difficult principles, situations or objects, like natural and physical phenomena.

As learning in the museum has always been a mobile experience, it seems that AR applications that could be run in a visitor- or museum-owned terminal could be very promising. However as with all the above discussed cases, this solution also presents some disadvantages. If the end-device has a very small display, the interaction surface is very limited. This was clearly illustrated in

Chapter 2, were we saw that the majority of mobile museum guide projects have either used PDAs or cell phones as delivery-platforms. In two cases TabletPC were used, which are more powerful but considerable heavier than PDAs. In the future the combinations of such devices with special see-through goggles could give new directions and inspire a lot of ambition to mobile museum guide projects, but for the time being, such displays are still very limited in capabilities and also extremely expensive.

In order to further examine this presumed potential of AR in the museum environment, we will progressively examine all phases of an experiment including the design, implementation and evaluation of a mobile AR guide, created for the museum of Fine Arts in Rennes, Brittany, France. As we will see further on, in Chapter 4, the main goals were to explore to which extent AR has the potential of helping navigation and object finding in the museum environment but also in the multimedia application and to investigate the impact of this approach and intervention on museum visitors. The first step to realize towards this direction and before even contacting the museum professionals was the creation of a comprehensive functions list. The process followed and the results obtained will be presented in the following chapter.

3.7 LIMITATIONS OF THE AR APPROACH

Clearly, AR might have a tremendous potential if introduced as a component of mobile multimedia museum guidance systems.

The first and most important feature coming from the very essence of AR technologies is that the full surrounding environment has the potential of becoming an interaction surface, overcoming the limits of conventional mobile displays (Damala et al., 2007a, Damala et al., 2007b). In addition, as in most museums museum exhibits are fragile, the visitor has the possibility of contemplating an object from all possible views and even interact with it so as to change it. Most importantly, AR makes the invisible visible, allowing thus to museum or school educators to teach effectively children about physical phenomena. This very same characteristic could allow a museum visitor to visualize the exact context of an exposed artifact, which is often crucial for the full appreciation and understanding of an object's use. In addition it seems more than probable that removing the reference point from the mobile museum guide application to the environment or object to which the multimedia reference points could help in bridging the gap between the physical document/object and its digital/virtual counterpart.

However one should also bear in mind the current limitations of the AR approach, linked mainly with the current state of the art in the field. And these are unfortunately numerous. The lack of robust, affordable and dedicated displays renders the proposed solutions heavy, expensive and fragile. The fact that no standard, widely adapted display exists complicates also the issue of HCI with AR applications. Indeed, the full surrounding environment has the potential of becoming an interaction surface. But when the computer or the portable display will have disappeared, how are we going to interact with this new world? Accurate, fast and robust tracking, especially in outdoor or changing environments constitutes a real barrier in AR applications and a domain still in full development. At the same time, there is a profound lack of dedicated authoring tools, making practically impossible even for computer literate museum professionals to embark on relevant projects. If finally they do so, they often have difficulties expressing their needs in terms of AR scenarios, as they are not aware of what they can expect from the technology (Damala, 2007a). Finally there exists also a certain lack in user-centered evaluation of the AR approach. As a result in many cases the claim that AR can indeed facilitate HCI remains just a hypothesis (Anastassova et al., 2007a). This scenery sometimes leads to incorrect motivations for proposing AR approaches, as illustrated by the scientists that claimed that AR can be a panacea for museums that can not provide access to handicapped visitors. Ideally, the discussion about the integration or not of the AR principle should not in any case shade the necessary requirements-analysis phase that has to accompany any mobile museum guide project.

3.8 DISCUSSION

This chapter introduced the multiple dimensions the term interaction acquires with regards to the use of mobile multimedia guides in the museum context. A brief examination of the evolution of the term interaction was followed by the domain specific approach of Aoki et al (Aoki et al., 2001)., who defined 3 entities with which the museum visitor will interact while using a mobile museum guide. Taking this definition forward, we enriched it by discussing 7 different variations of possible interactions and interaction entities during a museum visit, while using a mobile multimedia museum guide. We then looked into the modalities involved while visitors switch their attention from the physical (the museum and the museum objects) to the digital (the mobile application) and vice versa and pronounced the hypothesis that AR interfaces might facilitate this capital in importance task by building on the principle of intuitive knowledge as introduced by the cognitive psychologist Howard Gardner.

In order to better comprehend the potential of the technology and explore paradigms of use, an overview of AR basic principles was provided and a spectrum of possible mobile AR applications was presented. AR applications related with cultural heritage were examined in more depth through classification in five categories. Advantages and disadvantages of all five categories were also resumed and discussed with regards to the potential of AR for use in mobile multimedia museum guides. After having traced this way the possible advantages of the introduction of AR on mobile museum guides, known and existing deadlocks that could slow down the wide adoption of the proposed approach were also examined.

The next chapter will present the numerous steps undertaken in order to validate the potential of mobile AR in the museum setting, through the creation of a comprehensive functions' list and the participative conceptual and interaction design of a mobile AR-enabled mobile museum guide for the Museum of Fine Arts in Rennes, France.

PART B

"The environment is everything that isn't me"

Albert Einstein

"…I want to see my own reality…I just don't want it to be augmented"

Female student who participated in the experimentations of the Museum of Fine Arts in Rennes

«Il y a donc cette double émotion : l'émotion choc devant, pour moi, le coloris et, complémentairement, l'émotion de la densité de pensée qui est confiée à la peinture. Et c'est d'ailleurs ce qui me gêne dans la peinture : à travers ses matières, ses formes, il y a quelque chose qui pense et je n'ai que des mots pour en rendre compte, en sachant pertinemment que ces mots ne recouvrent pas l'émotion dégagée. Donc c'est le tonneau des Danaïdes. Je pourrais toujours remplir par des mots et des mots, je n'atteindrai jamais la qualité spécifique de l'émotion d'un tableau de peinture. Même quand un tableau, ou une fresque, a été compris, y revenir c'est affronter de nouveau le silence de la peinture. »

Daniel Arasse, Histoires de peintures

CHAPTER 4

DESIGN AND IMPLEMENTATION OF THE AR GUIDE

4.1 INTRODUCTION

In the previous chapter, the complex issue of interaction with mobile museum guides was put forward, providing arguments for the interest of examining the integration of AR technologies in mobile museum guide projects. The affinities between AR systems and intelligent cultural heritage applications were particularly highlighted.

This chapter aims to further delve into the numerous steps that were necessary in order to conceive, design, implement and assess a mobile, AR-enabled museum guide prototype that was used in order to contact and invite the local museum of Fine Arts in Rennes in participating in a common research project. It then presents the diverse necessary actions undertaken in order to come up with a new, specific to the Museum of Fine Arts in Rennes prototype, robust and rich enough in content, in order to be evaluated under real museum conditions.

4.2 A COMPREHENSIVE FUNCTIONS LIST

4.2.1 INTRODUCTION

Prior to the design of a new interactive product or application, it is important to identify needs and establish requirements (Cheng and Atlee, 2007). With regards to our research hypothesis - concerning the integration of mobile AR in mobile museum guidance systems- section 2.1, examining the role of mobile multimedia guides in the museum, and 2.2, where classification criteria regarding mobile museum guides were introduced, can provide considerable aid regarding the initial stages of requirements analysis.

However, another important and crucial parameter in order to come up with a successful product is to approach and understand the nature of the "problem-space" (or "action-space"), also defined as *"understanding and conceptualizing what is currently the user experience product and how this is going to be improved or changed"* (Preece et al., 2007). This can be achieved through user/task analysis and the generation of detailed task descriptions that can be further decomposed, so as to establish -at the same time- a basis of already existing practices on which new requirements can be build (Bowman et al., 2005, Preece et al., 2007).

Especially concerning our case study that proposes the integration of a still emerging technology in an already existing and tried out interactive product type, the compiling of existing and possible future mobile guide functions seemed absolutely necessary, in order to examine possible ways by which AR could alter and enhance already existing functions or become an inspiration for new ones.

4.2.2 AN INVENTORY OF MOBILE MUSEUM GUIDES FUNCTIONS

In order to identify needs, establish requirements, better understand the nature of the "problem-space" and lay the foundations for user/task analysis, a comprehensive functions list was created. Possible functions were collected through a thorough literature research, taking under consideration different types of possible museum objects on display (e.g. everyday life objects, paintings, sculptures, coins, manuscripts etc). This inventory was then used to populate a table (Table 4.1) that was at first discussed with history of art and museum professionals of the local University Department of History of Art (University of Rennes 2). Two of the authors' publications also put forward the importance of the issue of creating and populating a comprehensive functions list (Damala et al., 2007a, Damala et al., 2007b).

As the table is quite extensive (comprised of 29 functions in total), instead of discussing each function separately, only the necessary elements for reading Table 4.1 will be provided, as well as additional general remarks that can be applied to all of the included functions.

The 1st of the six fields of the table provides the name of the Function/Task. The 2nd field provides a description of the task and its context of use. The 3rd field presents illustrative use-case scenarios related with the function examined. The 4th field is named "class", because as we will see a bit further, in section 4.2.3, four types of functions were identified. The 5th field accommodates possible advantages, disadvantages or open questions related with each function. Finally, a 6th field examines in which way AR technologies and the AR metaphor can be of interest for the function in question.

A general remark that can be applied to all of the examined mobile museum guide functions is that two categories can be distinguished: The first category embraces functions indispensable to the guide but –ideally- invisible to the user. Orientation, geolocalization, live streaming, registration and logging visitors' actions, fall under this category. The second category of functions is more explicit for the visitor and forms the core of allowed/suggested interactions in between the visitors and the exhibits. In this category one can include the use of avatars and storytelling, the possibility to provide personalized souvenirs or merchandise or to bookmark parts of the visit. Trying to draw the line in between these two categories could ensure that the interdisciplinary teams formed for the design and implementation of the guide are more efficiently subdivided in discipline-appropriate tasks, thus shortening the human and material resources needed for the completion of a project (Damala et al., 2007b).

4.2.3 CLASSIFICATION OF MOBILE MUSEUM GUIDES FUNCTIONS

However, a closer look at the above inventory (Table 4.1) reveals that a more abstract taxonomy might also be deduced. Working further with the set of functions examined above, led to the distinction of four types of mobile museum guidance systems' functions: Contextualization, communication, personalization and museum data management.

1. Contextualization

Contextualization is a term initially used in biblical studies but steadily adopted from the 70s onwards a lot in cultural studies, especially archaeology, where the notion of "context" is of paramount importance (Renfrew, 2000). It is in this spirit that the term was chosen for our taxonomy, in order to express all functions that help a visitor re-place a museum object in its original context. A burial, for example, is constituted by a "closed" group of objects that when exposed obtain their full meaning only through examining the existing interrelations. This "dimension" is often lost in museum exhibitions (Pierce, 1994). The visualization of images, slideshows, 3D models, animations and avatars used as virtual guides belong in this category as well as the audio function, the speech-to-text or text- to-speech function or the video function. Granting to more initiated visitors access to the museum database and providing hyperlinks also belongs in this category as well as all functions allowing the manipulation of digital artifacts or 3D models.

Table 4.1: Inventory of Mobile Museum Guides Functions and Interrelations with AR

Functions/Tasks	Context – Description	Scenario - Examples	Class	Advantages/Disadvantages/Open Issues
Registration	Registration allows the coupling of a device and the consulted content with individual visitors. It is a prerequisite for computer assisted collaborative activities.	The visitor is registered together with other visiting companions. An e-mail address is registered. Information related to the visit can then be e-mailed or provided as a URL.	Museum Data Management	Protection of the privacy of visitor data
Augmentation: Not applicable. **Augmentation Prerequisite:** Yes. At a later stage, the type of interaction with the computer application might be influenced by the social context of the museum visit.				
Personalization/ Configuration	Unlike more traditional means of communicating information about museum objects, personalization allows adjusting the provided content to one's interests and abilities. -Age groups -Learning styles -Multi-lingualism -Personalized merchandise -Different output devices -Bookmarking -Communities -Disabilities -Thematic tours -Time available	→ Upon registration, the museum personnel configures the application. → During the visit, the visitor has the possibility to appropriately configure the application.	Personalization	Though the number of possible choices is important, a limited only, and easy to deal with subtotal should be available for museum visitors.
Augmentation: Possible. This category is vast (see also section 2.3.4). Difficult to talk in a generalized, non specific way about augmentation. Each personalization case study is different. **Augmentation Prerequisite:** Probable, depending on the type of personalization on focus.				
Geolocalization	Terminals are geolocalized. This function may be of use both for museum visitors and museum professionals.	→ The visitor obtains the right information on the right spot. → Visitors can locate their companions → Museum stuff may control visitors' flow during periods of great affluence.	Museum Data Management	
Augmentation: Possible. Different kind of information appears on the terminal depending on visitors' position and orientation. **Augmentation Prerequisite:** Geolocalization, in terms of 3D registration, is a prerequisite for all AR applications.				
Orientation	Orientation is as important as Geolocalization. Taking full advantage of geolocalization capabilities demands also an accurate knowledge of the orientation a visitor is	The visitor points his terminal towards a museum exhibit. Commented objects should be differentiated from non-commented objects.	Museum Data Management	→ Should it be taken for granted that information exists for all exposed exhibits? → If not, through which means the visitor can be aware of commented and not commented

<table>
<tr><td></td><td>looking at.</td><td></td><td></td><td>exhibits?</td></tr>
<tr><td colspan="5">Augmentation: Possible. Augmentation is strongly linked with an accurate knowledge not only of the exact position but also of the orientation a visitor is looking at.
Augmentation Prerequisite: Orientation is an important prerequisite for AR applications.</td></tr>
<tr><td>Live Streaming</td><td>→ Live streaming frees the multimedia tours from the restrictions related with the terminal's storage capabilities.

→ may also serve for automatic content update.</td><td>→ A stuff member updates all mobile guides simultaneously.

→ A visitor might be given the possibility to ask for on-demand content, if interested in an object not included in the standard tour.</td><td>Museum Data Management</td><td>Speed, processing power and memory of portable platforms as compared to PCs is still limited. Few museums have experimented with live streaming.</td></tr>
<tr><td colspan="5">Augmentation: Possible.
Augmentation Prerequisite: Not necessarily.</td></tr>
<tr><td>Object Selection /Object "recognition"</td><td>After orientation, selecting one among many other available objects is a task of outmost importance</td><td>An object among the enriched ones is selected. A 2 or 3D menu pops up.</td><td>Museum Data Management</td><td>How are included and not included in the guide objects differentiated?</td></tr>
<tr><td colspan="5">Augmentation: Possible. Selecting the object initiates the appearance of a computer generated menu, blended into the real surrounding environment through an appropriate display.
Augmentation Prerequisite: Yes.</td></tr>
<tr><td>Rotation, zoom-in and manipulation of artifacts</td><td>Museum objects are not always visible from all angles (e.g. pottery, coins etc) or visitors are discouraged to manipulate them.
This function allows the user to zoom in and out and rotate the artifacts.</td><td>A vase seen from all angles, two sides of a coin, a tool, an opened manuscript or book, a statue seen from all angles, zoom in a painting.</td><td>Contextualization</td><td>Through what type of controls the visitor manipulates the objects?</td></tr>
<tr><td colspan="5">Augmentation: Possible. The real object is augmented / replaced with a virtual 2D or 3D model that can be manipulated by the visitor.
Augmentation Prerequisite: Quite probably. Full interaction with AR applications can be obtained only if the augmented objects can be manipulated.</td></tr>
<tr><td>3D contextualization</td><td>A 3D model of an archeological site or the original context of an artifact could be superimposed around the exposed museum object.</td><td>With virtual tools a visitor could reveal the exposed object (example, e.g. virtual pit). The former environment of a sculpture, a pit in which a vase was found etc.</td><td>Contextualization</td><td>Could the visitor interact and view in 3D the environment? Through which means/controls could he/she interact with the virtual replica?</td></tr>
<tr><td colspan="5">Augmentation: Possible. The object's surrounding environment gets replaced by the natural or original context the object was found (e.g. a pit, a cave, a grave, a temple, a cathedral, a renaissance palace etc).</td></tr>
<tr><td>3D reconstructions</td><td>Often enough, museum objects exposed are not conserved intact. 3D reconstructions could help a visitor visualize how the original would have looked like.</td><td>Applicable to sculpture, pottery architecture etc</td><td>Contextualization</td><td>Same as in 3D contextualization. Could the visitor interact with the 3D reconstruction? Through which means/controls could he/she interact with the virtual replica?</td></tr>
<tr><td colspan="5">Augmentation: Possible.</td></tr>
<tr><td></td><td>The visitor is given the</td><td>After the visit, the bookmarks may be</td><td></td><td>→ Could generate additional revenues</td></tr>
</table>

Bookmarking	possibility to bookmarks favorite museum objects.	delivered by: → email → CD → print outs → web → personalized merchandise	Communication	for the museum. → Personalization → Favors long lasting relationship with the visitor → Lifelong Learning
Augmentation: Possible, depending on the system design.				
Picture it!	A photograph taken in a well defined area in front or together with an object and/or an avatar.	Visitors often tend to keep souvenirs from their visit. Taking a picture could function as a personalized souvenir that can then be delivered by: → email → printed photo → web → personalized merchandise	Communication	Though this function can be controlled by a mobile terminal, it has more the character of a multimedia installation.
Augmentation: Possible, depending on the system design.				
Text +Text to Speech + Personalized Text Rendering	The delivery media can change after an explicit demand from the visitor, e.g. a text can be delivered with audio, or read or presented by an avatar.	→ A visitor switches the mode of presentation from text to text to speech. → For older people larger fonts are chosen for the text.	Museum Data Management	Some people retain more information when they are told about it, others more when they read. Children for example have sometimes difficulties in reading and old people might benefit from the use of larger and bolder fonts.
Augmentation: Possible. For example, a text could be presented by an avatar that would thus "augment" the application, acting as an e-docent.				
Avatars **Avatars acting** **Story telling (avatar or human)**	1. An avatar as e-guide. It could be chosen and personalized with individual features. Furthermore, avatars could be public specific 2. Avatars could also be models illustrating with animation how certain artifacts were created or used, e.g. prehistoric stone tools – musical instruments 3. Avatar used as a story teller. 4. Sign language	→ a children avatar for children, a "specialist" avatar for already initiated visitors, an other one for the thematic exhibits. → a 3D drag and drop movement of the object to the avatar would make the avatar display how the object was used, worn, or made. → prefabricated questions could serve as starting points and plot controls for an object-centered story	Contextualization	
Augmentation: Possible. The real scene is augmented by personalized avatars that explain, demonstrate, narrate stories.				
	This function recognizes objects on which we find	→ A visitor chooses the "inscriptions"		

Inscription	visible inscriptions. It transcribes them, translates them and explains them. Can be also used for thematic tours (inscriptions).	thematic tour. → After contemplating an object a visitor asks to know what does the inscription on the object mean. → avatars could in this case also act as e-docents.	Contextualization	
Augmentation: Possible, depending on application scenario. The visitor terminal does not only display the inscription in question but also its transcription and translation.				
Video (situated documentaries)	The pictogram of a movie informs the visitor that there is a video presentation available for an object or aspect of it.	A visitor approaches an exhibit and finds out that a video is available. The video can be conventional or rendered in 3D (possible means: Virtual Reality, Augmented Reality, Augmented Virtuality)	Contextualization	Experiences have shown that people adore hearing artists/museum specialists talk about their work. Video is also used in all kind of museums and learning spaces as educational material. Movies should not be very long. If that is the case they could be split in shorter sequences.
Augmentation: Possible. A video is superimposed on the actual scene. Controls allow the user to play the video, pause it, and adjust the volume (volume control). With advanced AR configurations, the visualizations could also be delivered in 3D.				
Cartoon/ Animation	Painted figures or objects become alive. They jump out of paintings or vases and speak for themselves.	A visitor approaches an exhibit, realizes that an animation is available and activates it.	Contextualization	This kind of approach could be successful with children.
Augmentation: Possible. An icon, or pictogram, informs the user that an animation is available.				
Alerts	Visual or sound alerts could be used to inform about closing hours, beginning of films etc	While a visitor is visiting, an alert is activated concerning the beginning of a video/movie session	Communication	→ audio → visual → audiovisual
Augmentation: Only optical or audio. The message either pops-up on the display or gets activated by the user.				
Images/ Slideshow	A picture is worth a thousand words. Images could be used to compare with other works, see reconstructions, see earlier phases of a painting, building etc		Contextualization	
Augmentation: Possible. The object is augmented with a slideshow or a pictogram informing the user that there are photos available.				
Audio	Audio commentaries augmented with visual clues that refer to chunks of information. Audio information could embrace other arts as music and theater	A pictogram informs the visitor that there is an audio commentary on a particular exhibit.	Contextualization	
Augmentation: Possible. An optical augmentation (icon, pictogram) informs the user that there are audio commentaries for an object.				
	Logging visitors' actions gives a valuable mean of			→ Is 3D preferable than 2D? Which types

Logging in visitors' actions	assessing information, regarding: → application structure and content → favorite exhibits → favorite sequences		Museum Data Management	of presentation are more popular? Which objects? Is there any reason for that? → catering for visitors data privacy
Augmentation: No. This is a function related only with the assessment and management of museum ICT.				
"Sticky notes"	Visitors are encouraged to leave their comments on exhibits, in audio or text format.	A visitor approaches a work of art. → An alert or pictogram informs him he can leave a "post-it" note. → Alternatively we might encourage polls concerning certain works. →The visitor can consult what other visitors commented on an object.	Communication	Social interaction and public dialogue is encouraged.
Augmentation: Possible, depending on the application design. Context sensitive augmentation depending on the geolocalization of the users' terminal. A sound or icon/pictogram informs the visitor that there are comments available for the work of art he/she is contemplating. Another pictogram may inform the visitor that it is possible to leave a message.				
Access to Museum Data Base	Access to the documentation database could be granted for some profiles e.g. experts or student profiles.	A pictogram informs the visitor that database information is available for a work of art. (e.g. additional pictures, bibliography, other documentation)	Contextualization	→ This function could be of interest for specific profiles. → Good example of mobile guide function linking with already existing IT museum infrastructure.
Augmentation: Possible, depending on the content of the database.				
E-mail it!	The visitor can email in real time information or e-postcards of exhibits to home/friends.	The Pictogram launches an application that allows the visitor to send an e-postcard of what he/she is contemplating to a friend via e-mail.	Communication	May foster long lasting relationship with museum visitors, help in sharing the visit with remote friends and attract new public in the museum.
Augmentation: No.				
Short Message Service	Could give adult visitors the opportunity to communicate between them during the visit if found in separate rooms or locations.	A Pictogram launches the SMS application. The message is sent immediately to the terminal of the fellow visitor. Pre-constructed phrases could also be included: E.g. see you in the cafeteria in 5 minutes.	Communication	Should the communication be allowed only among co-registered visitors?
Augmentation: No.				
Museum Shop	Visitors would be given the possibility to consult whether associated books or objects are available in the museum shop. Could	Consulting the bookmarks, a visitor checks out what kind of relevant merchandise is available in the	Personalization	The visitor must feel in control of this function, and should not be "harassed" or overwhelmed.

	be linked with the "Bookmarking" function. Could be linked with the "Picture-It" function.	museum shop. (e.g. books, posters, mugs etc).		
Augmentation: Possible, depending on the system design. On clicking the associated icon/ pictogram the user can augment the view of the current exhibited object with matching merchandise.				
Museum Cafe	Through this function, a visitor could make a reservation for a table in the Museum Cafe.	A Pictogram launches the application. Tables' availability is shown on the display. The visitor selects a time slot and makes a reservation for a light meal.	Communication	A futuristic, but nevertheless absolutely feasible to implement function.
Augmentation: No.				
Interactive-AR games	→ dress the avatar → associate everyday life's activities with objects → observation/find the differences games → collaborative games etc	Scenarios for edutainment applications can be limited only by imagination.	Contextualization	Particularly interesting for young visitors that are fond of discovering through playing.
Augmentation: Yes, depending on the game's nature and the system design.				
Hyperlinks	Visual linking to other multimedia.	Hyperlinks are the backbone of the applications since all multimedia applications are launched through them.	Museum Data Management	Related with → structure → navigation → interface
Augmentation: Possible. Hyperlinks are a major kind of augmentation whether we are talking about the World Wide Web, interactive systems or augmented reality applications. Almost all of the above mentioned functions can potentially become hyperlinks.				
Way-finding	Way-finding assistance is provided when explicitly demanded by the museum visitor.	A visitor could use this module in order to ask assistance in locating a particular exhibition section or object.	Communication	Related with Geolocalization and Orientation
Augmentation: Possible. The actual surrounding environment could be "augmented" with signposting indicating the direction to follow.				

2. Communication

Another distinct set of functions is related with the issue of communication. Communication functions can assist different kind of communication needs, between the museum and the visitors, the visitors with the museum, the visitors with other co-visitors and eventually address the need of communicating parts or the full visit for later consultation, linking thus the pre, during and post-visit experience and strengthening the bonds of the museum with its public. The implementation of a "sticky notes" function, that would allow visitors to spatially comment exhibits could enhance the public dialogue around exhibits and engage more the public in the exhibition. Another example of a communication function is the real-time delivery of alerts regarding closing hours, or special events taking place in the museum.

3. Personalization

Personalization is another great advantage of the use of mobile guides in the museum setting and can be said to be a function of its own, composed by different sub-functions. In this report we use the term personalization with its general meaning, including as well configuration, and without strictly drawing a line between customization or adaptability, thought to be triggered by the user itself, and personalization or adaptivity, which lets the system induce the visitors preferences (Bowen and Filippini-Fantoni, 2004, Proctor, 2004). As already examined in section 2.2.4, there are many criteria upon which personalization can occur, like age groups, learning styles (Damala, 2007b), disabilities (Proctor, 2004), level of visitors initiation, available time for the visit (Damala et al., 2005), thematic tours, bookmarking, or social networks. On a more technical level personalization can also occur according to the terminal chosen and the available bandwidth.

4. Museum Data Management

Finally, there is a fourth category, completely invisible to the visitor that plays however a major role in the way the visitor will live the mobile museum guide experience. A common point among all these functions is that they deal with data (directed to the server by the devoted visitor's terminal or arriving as a response from the server after a request of the dedicated terminal). It is for this reason that we chose to name this category "Museum data management", with the term management embracing the storage, transmission and processing of data. Registration of visitors terminals, that allows museum staff be aware of the number of visitors in each room as well as logging in visitors actions belongs in this category, as well as geolocalization, orientation and live streaming. Modules for content creation, content management and content update can also fall under this category.

Of course, one has to bear in mind that though in the majority of cases it is relatively easy to decide in which category to place each listed function, there exist cases for which a function could be classed under more than one category. For example, logging in visitors actions can be classified both under the categories of "Museum Data Management" as well as under the category of "Personalization", since logging in visitors' actions could be used in order to propose personalized exhibit-related content. However, for reasons of simplicity and clarity each function presented in Table 4.1 is classed under only one category.

4.2.4 AR AND MOBILE MUSEUM GUIDES FUNCTIONS

In one of the author's publications, presented in October 2007 (Damala et al., 2007b), we supported that "there exists a set of AR functions" and that "their main impact to already tried out non AR functions is that they have the potential to change the way of interaction as the "scene" on which the action takes place can move from a tiny computer screen to the full environment surrounding as, through, for example the use of AR goggles. The same is true for the input and output devices that can be used to interact with the system".

Yet a more careful look in the table presented below, particularly in the 6th field presenting the possible interrelations between AR and each examined function, reveals that in reality the large majority of the proposed functions can as well be integrated in a mobile museum guide even without the use of AR. This also leads to the conclusion that AR capabilities are not a prerequisite but rather a medium through which the design, display and interaction with an interactive mobile museum guide can be altered.

4.2.5 CONCLUSIONS

This section presented an inventory of mobile museum guide functions, proposing also a classification scheme and examining the ways in which AR can enhance or alter each suggested function. The inventory can also serve as a pool of ideas for museum professionals for the definition of necessary or desirable functional requirements to be integrated in a mobile multimedia museum guide. The section also examined the interrelations between AR and proposed mobile museum guide functions. It also suggested that AR in the context of design and implementation of mobile museum guides is not a prerequisite but rather an alternative choice regarding interaction design of mobile multimedia museum guides.

4.3 DESCRIPTION OF THE 1ST MUSEUM GUIDE AR PROTOTYPE

4.3.1 INTRODUCTION

As already mentioned, the functions' inventory presented in the previous section provided valuable help regarding a more thorough understanding of the possible functions a mobile museum guide can integrate but also, more importantly, of the possible ways by which the final user experience can be shaped using AR technologies and the AR metaphor. The table created was also used during two brainstorming sessions conducted with a Professor of History of Art and Archaeology of the local History of Art Department (University of Rennes 2) who validated most of the possible functions as desirable and usable for the specified context of use. Some slight hesitations were only expressed for the more "futuristic" but also resources-generating functions (like, for example, proposing personalized merchandise at the end of the visit or providing an application module for making a reservation in the museum's café).

After this first validation of the functions list, the time came to proceed with the creation of some first mockups. However, prior to this activity a decision had also to be taken as to the platform on which the application would be delivered, given that the size and the controls of the terminal had also to be taken under consideration during the design process.

4.3.2 CANDIDATE PLATFORMS

For the delivery of the museum AR application three types of candidate platforms were considered:

1. Mobile phones and smart phones
2. PDAs (Personal Digital Assistants)
3. UMPC (Ultra Mobile PCs)

Mobile phones (including smart phones) provide a small interaction surface and often use proprietary, "closed", operating systems that prohibit system-level programming. In addition their memory (RAM) is limited and usually does not exceed 64 MB, while despite the evolution in the performance of the built-in cameras, the resolution is still very limited when it comes to video recording (320 * 240 or 160 * 120 pixels).

PDAs have been largely used in many museum mobile guide projects (see also section 2.2.8 and Figure 2.3a-2.3.g). Though in comparison with mobile phones, they are equipped with a larger screen, the interaction surface was judged too small regarding the AR application requirements.

Another reason for choosing UMPCs over mobile phones and PDAs was that UMPCs are much more performant in processing power and storage capabilities but also in terms of controls, as they are resemble more to PCs, at least comparing with mobile phones and PDAs.

Two different types of UMPC models were considered for use:

A) Samsung Origami Q1: This UMPC has a 7 inch LCD (Liquid Crystal Display) touch-sensitive screen, with a maximum resolution of 800 x 480. It weights 779 grams and measures 22, 7 cm * 13, 9 cm * 2, 6 cm. The Q1 is doted with a Celeron M processor of 900 MHz optimized for low power consumption (ULV), 512 MB of memory, and a hard disc of 40 GB. Bluetooth and Wi-Fi communication capabilities are integrated in the device as well as two USB 2 ports. Windows XP

Tablet Edition was the operating system at the time of the implementation of the final prototype (Figure 4.1).

In terms of user interface and controls, an 8-way direction joystick is present on the right side of the device as well as an enter/launch key. The right side also possesses a button of quick access to several UMPC functions. A major drawback was that in the version used, no integrated camera was available. A standard webcam was connected to the device using one of the two USB ports (Figure 4.1).

Figure 4.1: Front and back view of the 2nd candidate device equipped with a standard webcam

B) Sony VAIO UX series: This device has a 4.5 inch LCD touch sensitive screen with a 1024 x 600 pixels resolution. The processor is an Intel Core Solo U1400 running in 1.2GHz and the memory 512 MB. The hard disc can store up to 30 GB while the preinstalled operating system was Windows XP Professional SP2. The device has Wi-Fi and Bluetooth connectivity, 3 USB ports, an Ethernet port, a VGA output, a video-out, plus an integrated camera as in contrast with the Samsung previously described (Figure 4.2).

Figure 4.2: The 2nd candidate device considered the delivery of the application

Though the application run on both devices, it was the Samsung UMPC that was used for the main experimentations, as the smaller screen size of the VAIO rendered difficult the manipulation and legibility of the application.

4.3.3 CREATION OF A FIRST MOCKUP

After the requirements analysis phase and the release of the possible functions inventory, the creation of the first mockups followed (Figure 4.3, Figure 4.4, and Appendix IA). In order to further facilitate the deployment and implementation of a 1st prototype, it was also judged necessary not only to adopt a particular object type but also concrete case studies. For enabling a faster and more robust implementation, the 1st prototype focused on paintings, despite the fact that other object types (for example statuettes or vases) were also considered. At this stage, the possible scenarios were not only inspired by the inventory presented in section 4.1, but also from the particularities of two paintings adopted for experimentations in the lab, Jan Van Eyck's "Arnolfini" painting and Van Gogh's "Café Terrace at Night". One of the main arguments for choosing these two paintings was not only that they are very well known, but also that an abundance of information concerning them was easily available. The script of one of these two multimedia presentations is available in Appendix IB.

Figure 4.3 pictures a mockup showing a possible way by which visitors could be provided with way-finding information regarding a painting as well as a way for indicating other available commented paintings.

Figure 4.4 comes from the mockups created for the "Arnolfini" painting. When the painting is chosen or detected, the title, the date and the museum collection in which the painting belongs is displayed on the title bar. To the left, the three images refer to different themes available for each painting: The "When" theme provides information about the period in which the painting was created; the "Where" theme provides information regarding the place and context in which the painting was created; the "How" theme gives information as to the technique employed for the selected painting. On the top right two other images appear: The first one has the form of an open notebook, indicating that the visitor is able to create his own notes on the painting, while the call-out below indicates that the visitor can write and leave a spatial comment for the painting that will be later available for consultation by other visitors. The two other images below indicate that the visitor can e-mail the painting information or bookmark it in order to receive -after the end of the visit- all bookmarked objects with their comments in a CD or any other storage medium. The images below the painting indicate the different kind of media available: text, audio, music derived from the period in which the painting dates. The magnifying glass on the centre of the picture indicates that the visitor can zoom-in in details, for example magnify the mirror behind the depicted couple or the Latin inscription above it.

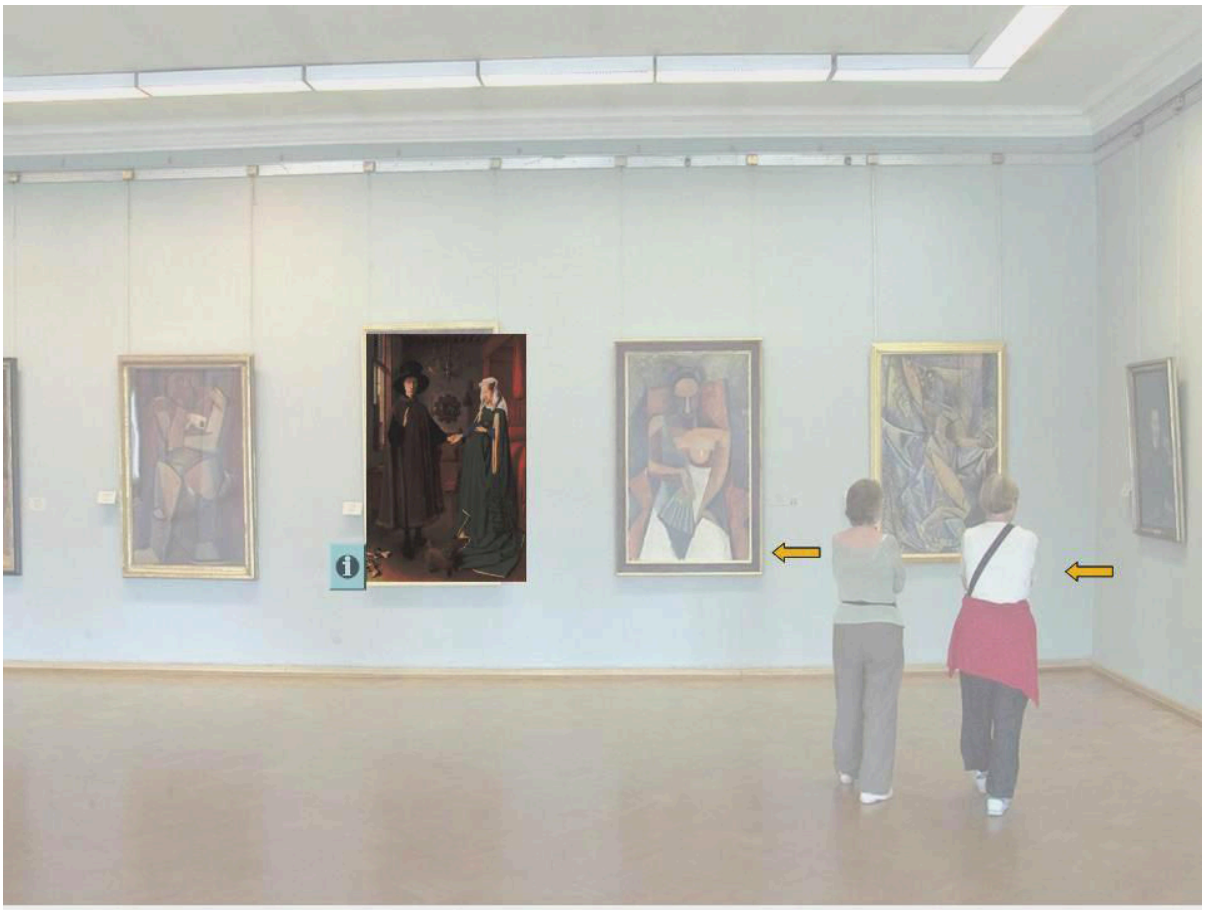


Figure 4.3: Mockup created prior to the implementation of the 1st AR prototype

This mockup provides a visualization example of a proposed interface integrating a number of possible functions presented in the functions' inventory. However, because of numerous difficulties related with the implementation, the 1st prototype could only include and deliver content in the form of text, audio, 2D and 3D slideshows. With respect to these constraints, the author created two scenarios, one for each painting (Appendix IB). After the finalization of the texts and the recording of several audio sequences, the content authoring took place.

The application was programmed in the host lab, using the C programming language and Microsoft Visual C++ as an IDE (Integrated Development Environment). The ARToolkit library (ARTOOLKIT) was used for tracking. In order to enable a more easy content creation without having to alter the code written, a special module allowed passing on important application parameters using appropriately formed XML documents (eXtensible Markup Language). In terms of architecture, the application was composed by two modules: The Magic Engine module and the

Magic Player module. The Magic Engine forms the core of the application and is responsible for the initialization, the 3D registration of the camera, the parsing of the XML files, the creation of the interface and the rendering of the objects that will augment the scene. The second module was the Magic Player (Magic stands for Mobile Augmented Guide For Indoor Collections); the Magic Player receives all relevant data as an input, so as to launch and "play" the presentations.

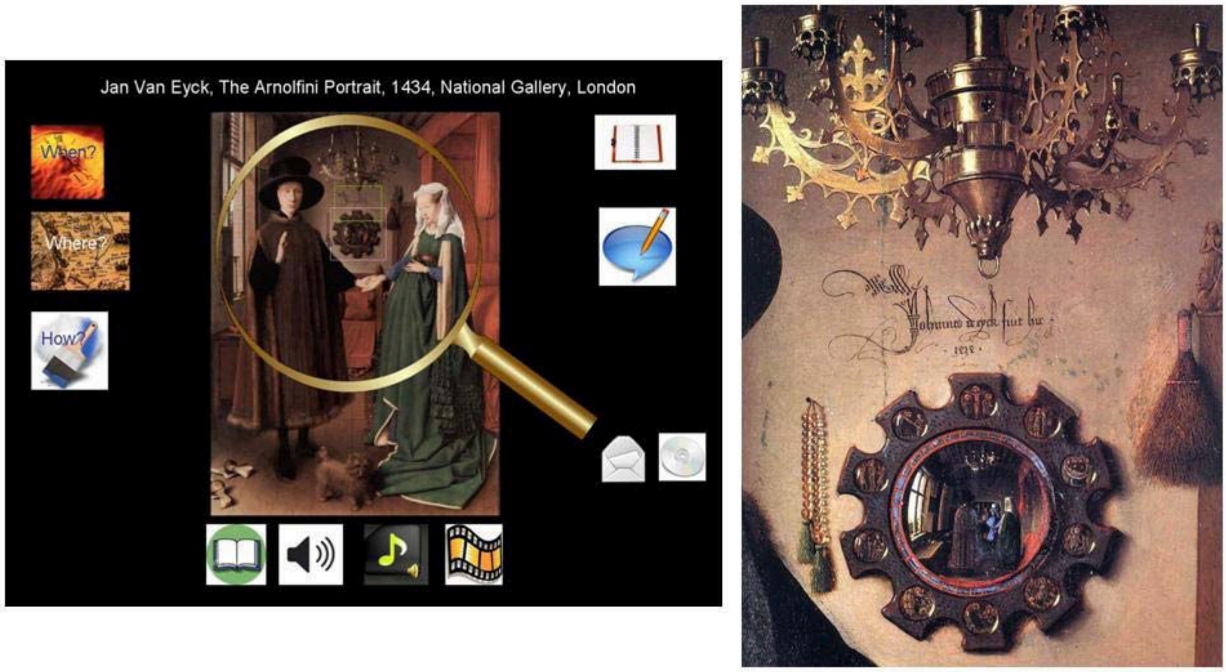


Figure 4.4: Mockup created prior to the implementation of the 1st AR prototype and detail

The guide was first tested in the laboratory, and then demonstrated on several occasions, among which the International 2007 Laval Virtual Conference using the Samsung UMPC described in section 4.2.1, with the addition of a standard webcam (Damala et al., 2007a). The user, holding the UMPC points the camera towards the two paintings. The screen is divided in two distinct frames, the ScreenSpace and the ARSpace. The AR Space displays the video captured in real time together with the augmentations of the real scene. It is surrounded and framed by the ScreenSpace on which five controls of the application are provided: an "exit" button, a "freeze" button, a "back" button, a "forward" button and a "pause" button. In addition, the ScreenSpace also displays the title, the artist and the dating of the painting as well as the dimensions, the materials used and the museum in which the painting is exposed (Figure 4.5).

The video captured in real time serves both as a background for adding up the virtual overlays but also as an input for ARToolkit that processes the sequences in order to detect the commented paintings. When a painting is recognized, the title bar appears on the ScreenSpace, providing information about the artist, the title of the painting and the date. On the right side, the appropriate information regarding the materials used, the dimensions and the museum where the painting is exhibited is displayed. The visitor can use the “freeze” button so as to capture a snapshot of the detected painting and the overlaid information without having to continuously hold the device at the height of the painting. The “forward”, “back” and “pause” button allow the control of the multimedia sequences provided for the painting, consisting of audio, text, and 2D and 3D slideshows. All content and sequences were linearly arranged; subthemes were available in terms of content but not visible to the visitor who had to navigate linearly from one sequence to the next one (Appendix IB).

Despite the modesty of this first implementation, in terms of interface, the proposed application, based on the AR approach, proved to be quite useful, as it generated rich feedback mainly as to the ways the content could be presented. It also provided a very useful companion and demonstrator when the first discussions regarding a possible collaboration with the Museum of Fine Arts in Rennes (Musée des Beaux Arts de Rennes) were initiated. In parallel a second version of the AR guide slowly started to take shape, taking under consideration the feedback resulting from the demonstrations of the 1st prototype but also directives regarding the use of specific tools and languages to be employed so as to ensure interoperability with other AR and VR related activities in the host laboratory (France Telecom Research and Development/Orange Labs).

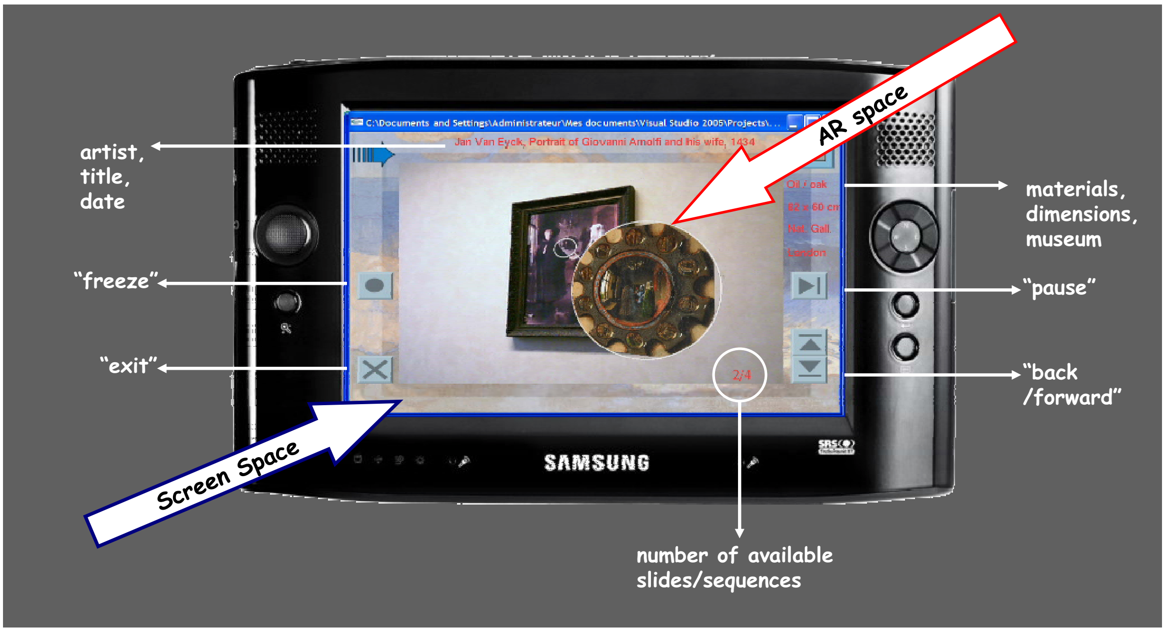


Figure 4.5: Snapshot of the 1st AR prototype

The design and implementation of this 1st prototype but above all its demonstration on numerous occasions was a first step towards establishing a basis for discussion with the municipality of Rennes and the local Museum of Fine Arts, as described in the next section.

4.4 MAIN STAKEHOLDERS MOTIVATIONS AND NEEDS

4.4.1 INTRODUCTION

Understanding the circumstances under which the experimentation took place is a prerequisite for the comprehension of the context under which the main research project was shaped but also for the understanding of the motivations and needs of the main actors that influenced one or more of the project phases.

After the engineering and first public demonstrations of the 1st prototype took place, the municipality of Rennes got contacted by France Telecom RD in order to explore the possibility of a mutual project together with the Museum of Fine Arts in Rennes. The municipality brought the lab in contact with the museum while positioning itself as a co-partner for the project. During the first meetings a demo was also presented to the museum professionals. The result was an agreement for the proposal of a research project, to be considered for financing by the French National Agency of Research (ANR - Agence National de la Recherche). All necessary actions were undertaken for the composition of the proposal, but in the meantime there was an effort of presentation of the relative PhD research project to the museum stakeholders, so that the first experimentations regarding a new AR prototype begin the soonest possible. The museum agreed and, shortly after, the first meeting in the museum took place in order to organize the following working sessions. It is important to highlight that the design, engineering, implementation and assessment of this museum-tailored 1st AR guide did not officially make part of the works regarding the proposal so whatever time and effort the museum professionals dedicated was voluntary.

4.4.2 THE MUNICIPALITY OF RENNES

The municipality of Rennes acted as an intermediate for contacting the Museum of Fine Arts in Rennes in order to propose a collaborative research project based on mobile AR for the museums' collections. A communication channel with the RD department of FTRD exists since many years, and among others, has resulted in the past, in a detailed 3D model of the city of Rennes and a visualization tool for accessing information on public services (location, opening hours, etc.), public transportation (location, timetable) and sport installations (Cavagna et al., 2006). As the use and integration of IT technologies in all aspects of civilian life is on the top of priorities for the local authorities, the municipality of Rennes was very interested in facilitating the contacts with the museum of Fine Arts in Rennes.

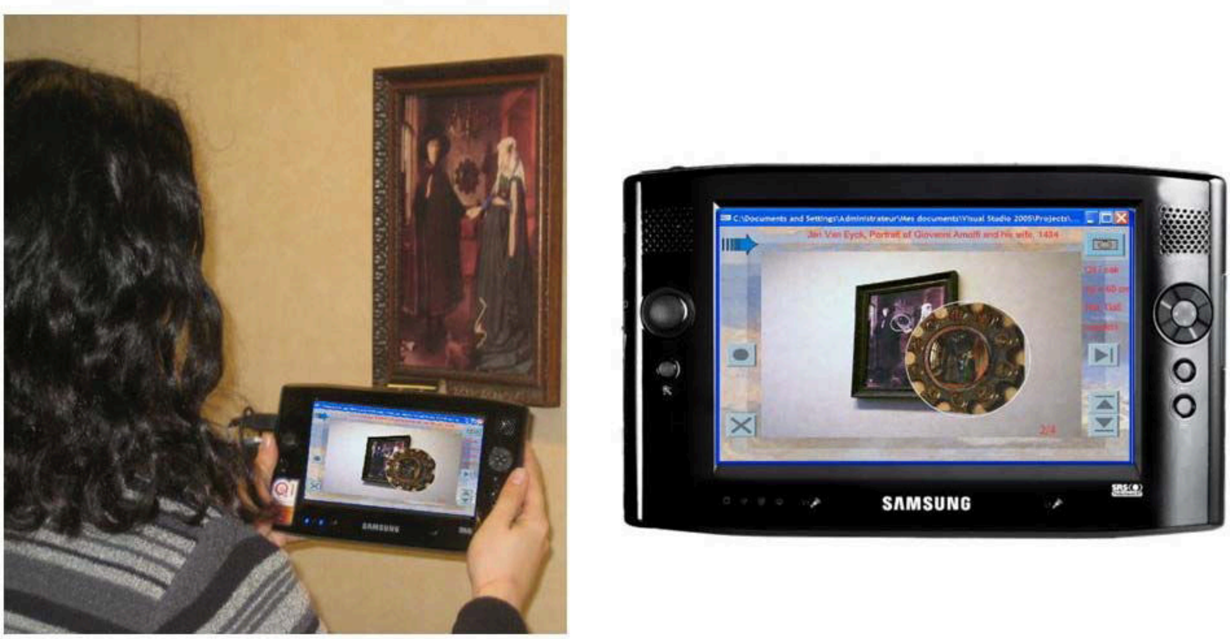


Figure 4.6: Testing of the 1st AR prototype in the lab

4.4.3 FRANCE TELECOM RESEARCH AND DEVELOPMENT (ORANGE LABS)

France Telecom is a telecommunications company benefiting from an "integrated operator" profile including the design, development, research and commercialization in varied fields such as Internet services, mobile telephony, networks and IT business solutions but also entertainment and related content creation. Despite the fact that up till today there is no particular lab dealing with Cultural Heritage related applications, in the past several related commercial and research projects have been realized (Damala and Bouville, 2006). Among them a system for the complete recording and documentation of artifacts in the underwater excavations realized in the port of Alexandria, two other mobile museum guides projects, DANAE and Mobivisit (discussed in detail in sections 2.3 and 2.4) but also e-tourism applications and 3D intelligent avatars.

The corresponding lab for the AR museum guide project was IAM, a laboratory that has been mainly focused in 3D and Virtual Reality applications and which lately develops various activities related with AR technologies.

Conducting experimentations in real-life, indoor, environments -especially in the contextually rich museum ecology- was seen as a step towards mastering not only more complex AR applications for outdoor use but also towards achieving the creation of full-fledged, multimedia, AR applications to be used in other indoor and outdoor environments.

4.4.4 THE MUSEUM OF FINE ARTS IN RENNES

The Museum of Fine Arts in Rennes is dependent from the French Ministry of Culture but also directly linked with the Municipality of Rennes that acted as an intermediate for the common project. The museum has an active policy regarding the use of Information Technologies, a great sensitivity towards fulfilling its public diverse needs, and -as wee will see in the next section- had already been implicated in the development of interactive edutainment applications.

For the museum of Fine Arts in Rennes, participating in the project meant implication in the design of one additional, alternative, educational resource. The avant-gardism of the AR approach comes with the stake of several constraints imposed by a still evolving computer science discipline but with the advantage of tailoring a new educational resource for the very particular museums' needs.

4.5 THE SETTING OF THE MAIN STUDY

4.5.1 ABOUT THE MUSEUM AND ITS COLLECTIONS

Like most museums in France (Schubert, 2000), the collection of the Museum of Fine Arts in Rennes was constituted after the French revolution from works that were confiscated from civilians and the church (Coulon et al., 2000). However it also acquired the cabinet of curiosities of Brittany's parliamentary Christophe Paul de Robien (1698-1756) which was one of the richest "curiosities" collections in Europe comprised by objects from all continents and periods (Greek, Egyptian and Roman antiquities but also sketches of artists like Leonardo de Vinci, Botticelli, Dürer and Rembrandt). In 1810 and 1811 it was also enriched by state loans and donations. In addition, the museum houses a very important collection of works of modern and contemporary art and each year organises several temporary exhibitions

4.5.2 MUSEUM DOCUMENTATION POLICIES

The documentation system used by the museum is "micromusee"©, a software highly appreciated in many national museums in France. The main entries of the catalogue are also publicly available in the French database "Jokonde" (http://www.culture.gouv.fr/documentation/joconde/fr/pres.htm), a collective French national museum database that boasts more that 347.000 entries. However, as explained later and observed in practice, the more "traditional" paper folders, containing various kind of information, continue to be used, alongside with the museum databases. The museum also hosts a library accessible to students and researchers.

4.5.3 EDUCATIONAL POLICIES AND RESOURCES

In terms of educational policies, the museum offers a great variety of educational programs and workshops, available for different target groups, ranging from children (Figure 4.7b), to adults (Figure 4.7a) and visitors with special abilities. Educational material is also present in the web site of the museum alongside with the full contents of the published catalogue of the exhibition. Podcasts for selected works of art can be freely downloaded from the museum's web site. The commented works are designated in the exhibition space using a CD as a marker (Fig. 4.8a).

4.5.4 THE MUSEUM AND ITS RELATION TO NEW TECHNOLOGIES

Available podcasts and the use of databases are not the only affinities of the museum with New Technologies. Interactive kiosks are available in the museum, for visitors wanting to consult them while the participation of the museum in the "FRAME" project (French Regional and American Museum Exchange, http://www.framemuseums.org), resulted in the creation of an online interactive game for children, the "Room of Wonders", available in English and French (Fig. 4.8b) (Moonan, 2007). The museum's website (www.mbar.org) contains information about the collections, the history of the museum, but also the educational policies and diverse educational resources. Recently the museum also undertook the creation of a monthly newsletter.

Figure 4.7a-4.7b: a. Guided visit in the museum of Fine Arts in Rennes. b. Hands-on educational activities in the museum

4.6 LIFE CYCLE OF THE MAIN AUGMENTED REALITY PROTOTYPE

4.6.1 AN INTERDISCIPLINARY APPROACH

The particular nature of the planned intervention also manifested itself in the number of the professionals involved, at least during the early stages of the project. For example, the museum initial team consisted of a museum curator, all four museum educators, the Internet and new technologies head as well as the head of the public relations and communication of the museum. The team of the host research lab consisted of two R&D engineers, an ergonomist and the author. To this total of 12 professionals one should add the representative of the Municipality of Rennes, who acted as an intermediate between the museum and the lab, as well as a student in internship in France Telecom R&D who participated in the implementation of the guide. As the design process gave place to the implementation, other professionals also participated, as was the case with the museum photographer and two France Telecom R&D lab assistants that greatly helped the capture of video data during the evaluation process.

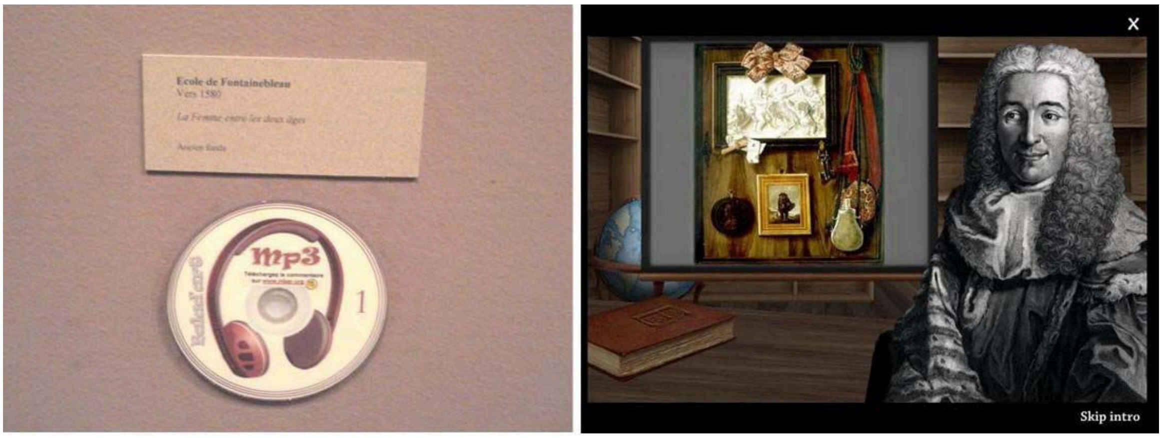


Figure 4.8a-4.8b: A. CDs used for signposting the existence of mp3 commented works, B. screenshot of the interactive game "The room of wonders" (http://www.framemuseums.org/sites/room_of_wonders/intro_en.html)

4.6.2 CONCEPTION AND DESIGN OF THE MUSEUM OF FINE ARTS AR GUIDE

Prior to the first meetings with the contributing museum professionals, the museum curator and occasionally the appointed museum educators, a thorough research regarding museum educational and IT policies was undertaken, using varied resources, such as the museum publications and educational resources (http://www.mbar.org/services/ressources/index.php), the museum website, interviews with the museum professionals but also participation in activities such as children workshops (Figure 4.7b) and guided visits for adults (Figure 4.7a).

The first meeting with the museum occurred in the summer of 2007. As expected, the first steps consisted of discussing with the museum professionals the notion of introducing mobile guides in the museum setting. Examples of other relative museum experimentations were discussed as well as anxieties regarding the effect of introducing a gadget-like interpretation medium in the museum premises, similar to the ones treated in section 2.6. The first prototype that used the Van Eyck and Van Gogh paintings was also revisited and displayed in order to better illustrate the notion of Augmented Reality and the way it could be used in the museum. These steps were crucial as the museum did not have prior experience with mobile guides neither acquaintance with the term Augmented Reality and the associated technologies.

4.6.3 SELECTING THE PAINTINGS

At this point of the collaboration with the museum, the first prototype stopped being used as a guide for the implementation of the second prototype. Only one prerequisite was maintained: the ability of the already developed application to detect and recognize particular paintings in the museum. As already seen, in Augmented Reality systems, the effectiveness of an application principally lies in the ability of a system to detect and recognize in real-time, elements of the surrounding environment so as to "augment" them. This ability is influenced mainly by two factors: the effectiveness of the embedded algorithm and the capacities of the equipment used. Especially in a museum, where the display conditions such as lightening, reflections, or the shape of the picture frames, cannot be adjusted, the application had to be reliable under all circumstances.

Since at this point the available algorithms were still under constant evolution, it was necessary to carry out numerous tests in the museum premises, so as to establish a list of "easy-going" paintings that would not risk neither to perturb the application nor –as a consequence- to frustrate the participants. A list of 9 paintings was dressed and then presented to the museum curator and the museum educators (Figure 4.9). Five paintings were retained using as a criterion pedagogical considerations and a common thematic axis: costumes and dressing. Later on, one more painting was excluded due to the lack of adequate interpretation material in order to be presented to the wide public. The four paintings (Figure 4.10) were:

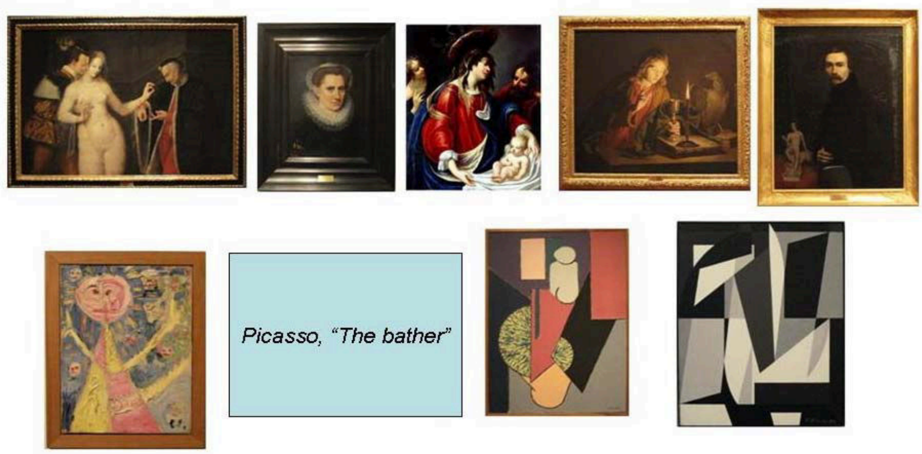


Figure 4.9: Initial list of paintings

a. An anonymous painting of the 16th century titled "Woman in between two ages"

b. Georges Lallemant's "Saint Family",

c. a 19th century self-portrait of the painter Eugene Amaury-Duval

d. Picasso's, "Bather"[1].

Figure 4.10: The four selected paintings

Despite the fact that the official collaboration would not start before January 2008, the museum affirmed a strong attachment regarding the content to be delivered and undertook the responsibility to assist throughout the full process of content creation.

4.6.4 DISCUSSING ABOUT THE TARGET GROUP AND THE EVALUATION SESSION

The next important topic to introduce was the target group or more precisely the visitor profile to which this prototype would be proposed. Suggested groups included children, as well as seniors and young visitors but finally there was a mutual agreement in that young people between 18 to 30 years old could be the most interesting of all of the proposed target groups. This target group was presumed to be more at ease regarding the use of information technologies compared with senior visitors and less susceptible to be influenced by the gadget-like character of the intervention in comparison with children. In addition young visitors of this age group represented a, "critical" according to the museums representatives' words, public.

The museum professionals were further encouraged to express their position regarding the evaluation process that would follow and were invited to participate. Despite their strong interest in evaluation and assessment, the museum partners stressed out that they were open in hearing proposals. The known facts at this point of the experimentations were that due to the highly experimental nature of the guide and the study, a qualitative rather than quantitative approach should be adopted and that a combination of various methods would seem more appropriate (as to the issues concerning evaluation, see also Chapter 5).

Like with the process of content creation, the museum assumed an important role regarding the recruitment of the candidates and proposed to contact two different university departments, the local School of Fine Arts and the Technical University Institute of Social Sciences. The hypothesis here was that the students of Fine Arts would be more "experienced" and demanding museum visitors in comparison with the 2nd group of students.

The final evaluation protocol finally prepared and proposed to the museum professionals is further discussed in the 5th Chapter, Methodology for Evaluation and Data Collection section and in Appendix IV. The next section presents the architecture –in terms of implementation- of the Museum of Fine Arts prototype.

4.7 DESCRIPTION OF THE 2ND MUSEUM GUIDE AR PROTOTYPE

4.7.1 INTRODUCTION

As we already saw, the 1st prototype was programmed in C and used the ARToolkit library for the identification of the commented works and their annotation with virtual widgets. Some of the most basic principles already present in the 1st prototype, for example, the use of XML files for the separation of each presentation parameters from the actual 3D rendering application, were kept intact. In a higher level, the separation of the PaintingGuide between two different modules, the "Magic Engine" and the "Magic Player" was also to be kept. In terms of hardware, the same configuration was used as with the 1st Prototype.

However, two important elements underwent important changes: In the 2nd version the package ARToolkitPlus had to be used instead of the ARToolkit library. An important change also occurred regarding the rendering engine, where Ogre3D had to be chosen, in order to ensure interoperability with other AR and VR applications under development in the host laboratory. The next section provides an overview of the tools that were used for the final prototype as well as information regarding the architecture of the application and the interactive features of this version.

[1] The copyright for the use of the Picasso's painting belonging to both the Museum of Fine Arts in Rennes as well as to the Picasso Foundation makes impossible the reproduction of the painting without a special permission.

4.7.2 SYSTEM PIPELINE AND IMPLEMENTATION TOOLS

As most typical AR systems which use a single video source both for tracking and see-through display (Wagner and Schmalstieg, 2003), the processing pipeline was composed of the following main tasks: Video acquisition, tracking, application computation, rendering and display. In the particular case of the museum of Fine Arts, the video is acquired by the webcam attached to the UMPC. Then the application checks whether the video frames contain one or more known patterns. When a pattern – a particular painting in our case- is detected the application computation and the rendering follows in order to obtain in a single display the combination of the real object, the painting, with the virtual, e.g. an avatar acting as an e-docent. (Figure 4.11). As in the 1st prototype, the AR scene is composed by the ARSpace, that uses the video acquired in real time as a background for the display of virtual, 3D-registered objects and the ScreenSpace that frames the ARSpace in which buttons or textual information may appear (see also section 4.2.3).

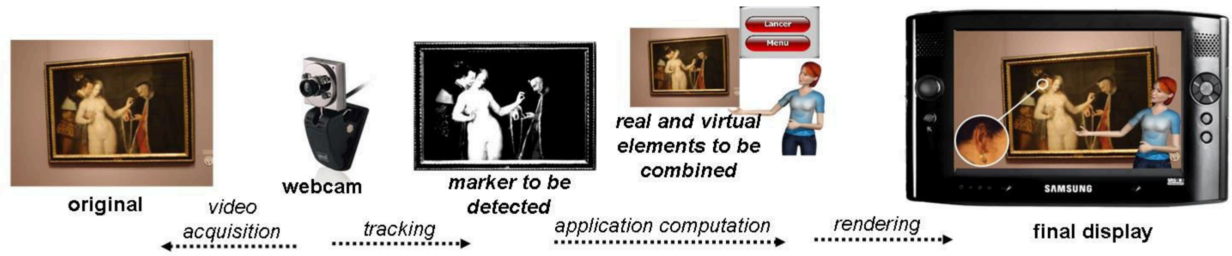


Figure 4.11: Pipeline of the Museum of Fine Arts Augmented Reality Guide

4.7.3 IMPLEMENTATION TOOLS

For the implementation of the application, the following tools and software packages were used (Jouvin, 2007):

- Video acquisition and Tracking: For video acquisition and tracking, ARToolkit Plus was used and a webcam Plug-in of Ogre 3D (presented below). ARToolkit and ARToolkitPlus are software libraries that facilitate the implementation of AR applications, using video tracking capabilities in order to calculate in real time the camera position and orientation with respect to the markers provided. ARToolkit Plus was especially conceived for low-end devices where often memory and processing power is much limited comparing with PCs. However, a serious disadvantage is that this free version is no longer supported and that compatibility with ARToolkit is broken because of the C++ based API. Together with the ARToolkit+ package, OpenCV, a well known multiplatform computer vision library, focusing mainly on real time image processing was also used for the capture of the webcam sequences.

- 3D Application Rendering: OGRE 3D (Object-Oriented Graphics Rendering Engine) was the 3D rendering engine used for the AR application. Ogre3D is written, as ARToolkitPlus, in C++. Its object-oriented design provides an interface based on world objects and other intuitive classes and benefits of a plug-in architecture that makes it highly modular. OGRE 3D also supports the OpenGL (Open Graphics Library) and Direct3D libraries while remaining multiplatform.

- 2D Application Rendering: For the rendering of all 2D elements (buttons, display bar, image etc) the CEGUI (Crazy Eddie's Guide User Interface) API, a C++ graphical user interface library compatible with Ogre3D was used.

- XML parsing: XERCES is the XML parser that was used. XERCES gives executables the possibility to read but also write XML data. It is conformant with the XML 1.0 and 1.1 versions while a library is provided for parsing, generating, validating and manipulating XML documents.

- Application Audio: Finally OpenAL (Open Audio Library) a free, cross-platform audio API, was used for the manipulation and delivery of the audio files of the application.

4.7.4 ARCHITECTURE OF THE 2ND AR PROTOTYPE

As we saw in the previous section, the input provided by the museum visitor is the filming or "scanning" of the surrounding environment with the web camera. When a painting is detected, virtual widgets appropriately positioned, appear on the screen and guide the visitor's navigation in the available content for each painting. The schema in Figure 4.12 reveals the architecture of the new prototype, the principal application components and the system's pipeline. However, a more careful look reveals that the system architecture obeys the general architecture abstraction provided by Williams et al. (MacWilliams et al., 2004), where a common basic architectural structure for AR systems is presented. According to this model, each AR system can be decomposed in six core subsystems: The Application subsystem, the Interaction subsystem, the Presentation subsystem, the Tracking subsystem, the Context subsystem, and the World model subsystem.

Application Subsystem: Magic engine is the core engine and the module linking all of the other APIs used for the application.

Tracking and World Model Subsystem: The video is captured by the Webcam Plug-in that uses the OpenCV library. The images captured are sent to the ARToolkit who is provided with a list of markers that should be detected in the captured image using computer vision algorithms. The output of this process is a transformation matrix, allowing the calculation of the position and the orientation of the camera regarding the identified marker. The matrix is then transferred to the engine of the application and more precisely to the AR Listener module. The video sequence captured is then used as an Ogre 3D texture and serves as a "background" for the application.

Context Subsystem: The context subsystem in our case is the module AR Listener. AR Listener manages the display of the augmented elements of the application having gathered all different types of context data. It creates and initialises a "tracker" -ARToolkitPlus- object, indicates the different markers ARToolkit has to detect in the captured image and takes under consideration any input the user might provide in the meantime or any other input coming from the XML parser or the sound manager.

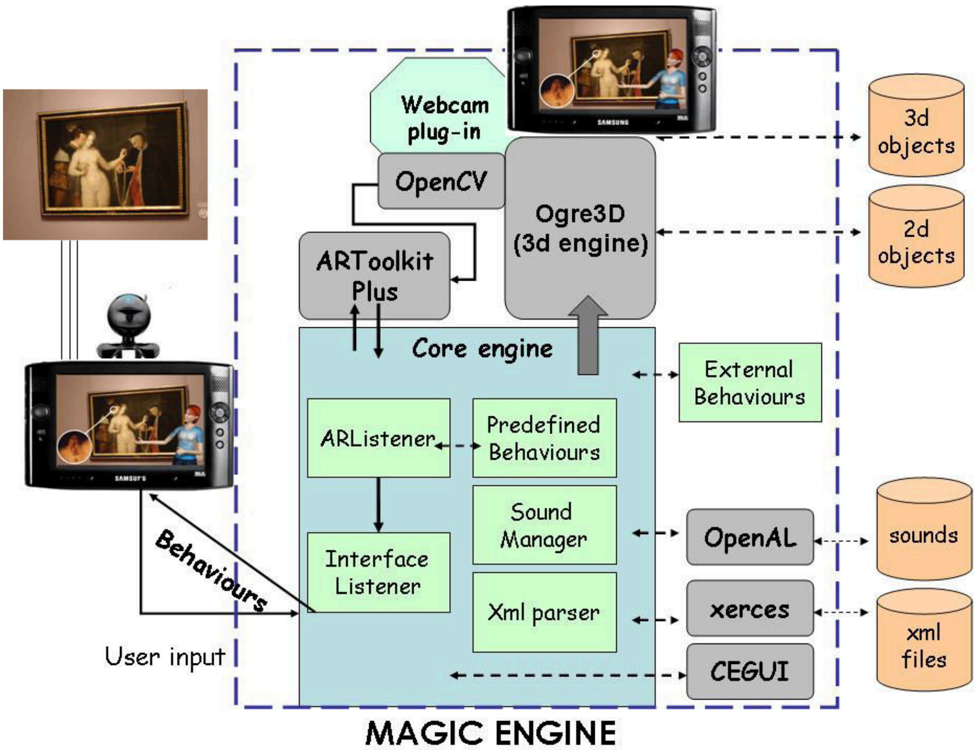


Figure 4.12: Architecture of the 2nd AR prototype (illustration extracted from (Jouvin, 2007)

Interaction Subsystem: The interaction subsystem of the application is a module named Interface Listener. This module gathers and processes any input that the user makes on purpose when the 2D or 3D menus appear after the painting is detected while also controlling both the ARSpace and the ScreenSpace viewports. The ScreenSpace viewport is also partially managed by the CEGUI (Crazy Eddie's Guide User Interface), a plug-in used by Ogre3D for adding up all the

2D elements (buttons, display bar, images etc) and for associating a behaviour and function to every event (click, double-click, mouse rollover etc.), either predefined (freeze, quit, etc.) or defined by the user, using XML files.

The “predefined behaviours” are executed every time the guide is activated and can only be programmed by an experimented programmer. An example of a predefined behaviour is the “freeze” function and the display of multimedia files.

The “external behaviours” module allows the definition of behaviours outside the core engine through modification of the XML files and is more accessible to content authors that are non-programmers. Some examples of external behaviours that can be defined using the XML language are: the definition of an input device (joystick or mouse) or the definition of a particular action to be taken once a 3D object is activated.

Presentation Subsystem: For the final rendering of the application, the core engine relies on Ogre 3D, the 3D rendering engine of the application. When Ogre 3D is instantiated two scene managers are needed, one for the ARSpace and one for the ScreenSpace (Figure 4.5). The organisation of the "Scene Manager" can be modified by adding a new rendering system, like Direct3D or OpenGL, or by providing another pool of data for example, an Internet site or a database. This separation of the graph of the scene and the content is said to be one of the most brilliant ideas of the Ogre 3D team. In order to interact with the scene, the two frame listeners, AR Listener are Interface Listener are also added to the Ogre 3D root.

The most significant classes in Ogre 3D are:
a) "Scene Management": controls the content of the scene, its structure as well as the way and angle by which it is seen by the camera.

b) "Resource Management": every 2D or 3D rendering necessitates resources that can be 3D objects, textures, fonts etc. It is therefore important to control the way these elements are loaded, the way they are used and the way they are manipulated if they are not needed.

c) "Rendering": refers to the final visualisation of the scene on the selected display. This part concerns the lowest level of the rendering chain. The "Scene Management" cooperates with the "Rendering" classes for the final rendering of all components of the scene.

Application authoring: In order to facilitate the authoring of the AR applications, many important and necessary parameters are passed to the core engine using XML files (Appendix III).

These are analyzed by the parser XERCES. Four different types of XML documents are used in the application.

a) MagicEngineParameter.xml: This XML file contains data regarding the position and the dimensions of the AR Space (the main frame) of the application but also the location of a separate file containing information relevant with the calibration of the camera.

b) MagicEngineGUI.xml: This XML file contains data regarding the modes of selection and activation of the different elements of the interface. All interface elements may appear either in the viewport ARSpace and/or in the viewport ScreenSpace (Figure 4.5).

c) MagicEngineItem.xml: This document is the most important of the application as it includes all the pointers to media and files that will be used for a particular painting presentation. For each museum object included, one *MagicEngineItem* is necessary. After the definition of the tracking method to be used, the location of the pattern to be detected is defined. Then what follows is the description of the "augmentations" or widgets that will appear, once the painting is detected. These graphic elements are grouped and can be of two types, either 3D objects ("3DObjects") or rectangles ("Frames") on which a texture can be applied. The attributes of both these categories are "position", "rotation" and "onAction".

d) MagicEnginePresentation: This document is linked with the different types of presentations that can be launched when a widget is activated. A presentation consists of a parade of different media sequences (see also section 4.8.3).

The process followed in order to acquire, process and prepare the "raw" content that was used for the application authoring is described in the next section.

4.8 PREPARING THE CONTENT

4.8.1 INTRODUCTION-DEFINING THE NOTION OF CONTENT

During the numerous meetings that took place with the author's academic supervisors, other members of the participating research unit of France Telecom R&D department and the museum professionals (museum educators, curators, history of art professors), it became apparent that the meaning attributed to "content" was not the same for all of the involved stakeholders. In terms of computer science, especially in terms of virtual and AR environments, the word content is usually related with the resources needed to author 3D content, like for example 3D objects, meshes, or other "materials" needed to stitch a 3D-registered interactive application. For museum professionals, on the other hand, the word "content" refers in most of the cases, to the actual educational material that will be delivered through a multimedia application.

The preparation of the educational content that would be embedded in the application was one of the most complex tasks of the full procedure. As at this phase of the project there was no financing, neither an officially launched project (with the exception of this thesis project that would be a kind of pilot for the forthcoming, two years and a half project), it was only possible to count upon the availabilities and volunteering of the museum personnel. It is important to repeat here, that the museum representatives ruled out the possibility of content creation without their explicit involvement. At the same time it became pretty obvious that the first and most important phase of content creation should take place in the museum, as it was not possible to treat documentation material outside the museum premises.

Another very important factor regarding content creation was that at this stage of the project and despite the fact of holding long discussions about mobile museum guides and the potential of Augmented Reality, the museum had no past experience relevant with the experimentation. It was therefore essential to join efforts so as to better comprehend the kind of information that could be included, and in particular the kind of information that would be better revealed using the Augmented Reality metaphor. The only plausible way to achieve that was by working closely with the museum curator and educators in all phases of content creation.

The scenarios creation and the successive content authoring included two iterative phases: content and scenario creation in the museum, and content and scenario creation in the lab.

4.8.2 CONTENT CREATION IN THE MUSEUM PREMISES

Regular meetings were organized in the museum between the author and the implicated museum curator, who acted as a medium between the writer and the museum educators. The meetings took place once or -at the most- twice a week, according to the availability of the museum personnel. Meanwhile communication was established through email and phone calls.

The first step was to examine the documentation available for each painting meticulously. Despite the fact that the museum uses different database systems for the documentation of their collection, the full documentation records still reside in hard paper folders where all sort of information gets gathered (Figure 4.13a-13b). The nature of this information is diverse, ranging from available publications and bibliography concerning the painting, correspondence of the museum with institutions and researchers regarding the painting, restoration interventions, even examples of reproductions of the paintings used in a non museum context (Figure 4.14a-14b).

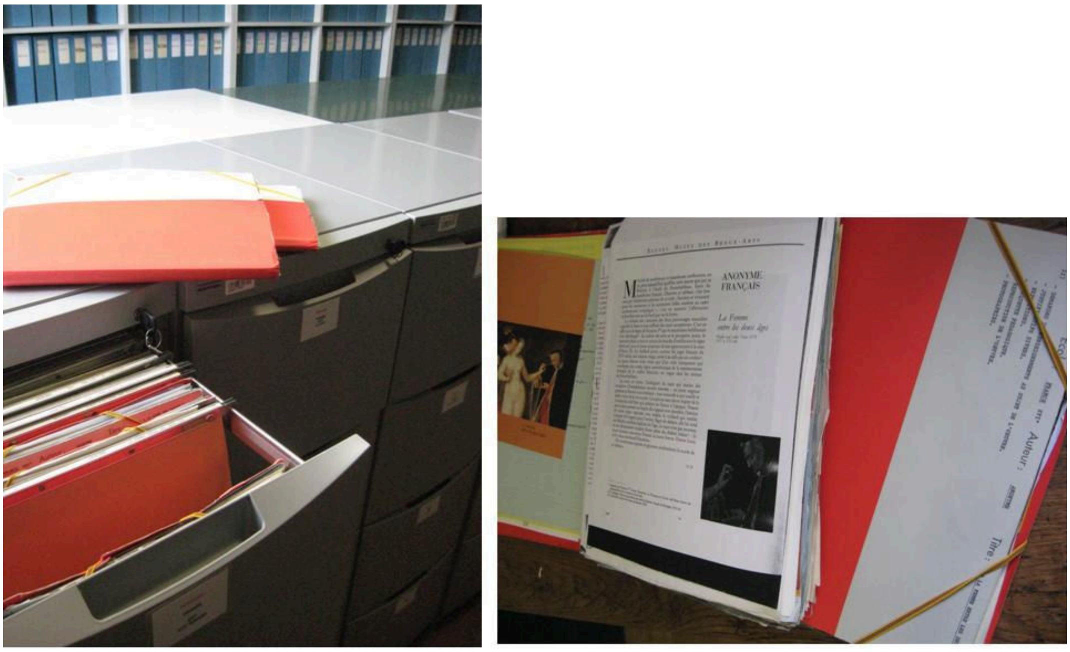


Figure 4.13: The physical archive of the Museum of Fine Arts and example of the folders used for the content creation (courtesy of the Museum of Fine Arts in Rennes)

The diversity of the available material gave many ideas as to the scenario and the content of the commentaries for each work. One of the most characteristic examples comes from the documentation folder of Lallemant's "Saint Family". The folder contains ultraviolet and infrared photographs of the painting which show that there were posterior interventions in the painting. That gave the idea of mapping the parts that had been repainted at a later date, onto the real painting. In the case of "The woman in between two ages" the author was surprised to see that the painting had been used as a cover for two books and a music CD (Figure 14a-14b). That gave the idea that in a future presentation there could be a thematic section regarding the influence and impact of the painting in the modern era. In another case, a visitor's letter dating from the 1st quarter of the 19th century was discovered and joined the museums' documents collection.

Because of all these new, rich input as well as the diversity of the available documentation material, museum professionals were advised to try to establish common thematic axes for all of the presented paintings. The museum came up with the following thematic axes that finally composed the available themes for each commented painting:

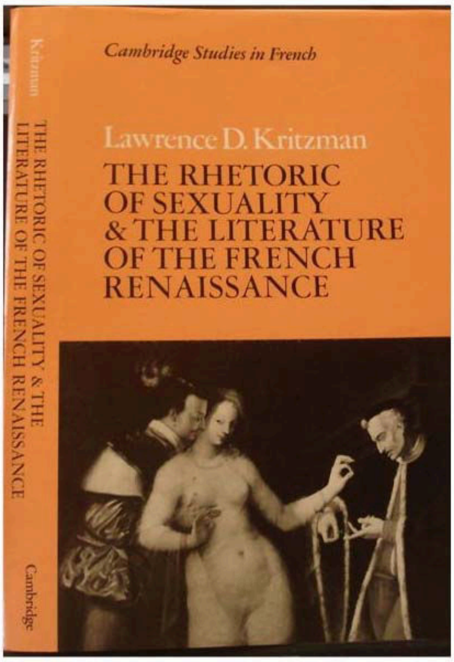
1. Description, where a description of the painting would be provided, paying particular attention to the iconographic elements that would facilitate the "decoding" of the depicted subject

2. Technique, where observations regarding the technique employed for the creation of the painting would be exposed

3. Iconography, where more information about the iconography of the theme, or other iconographic parallels (same theme, or other works of the same artist) would be available.

4. Context, where the focus would be on the social, artistic and historical context of the period in which the painting was created

5. Artist, where relevant information about the artist biography would be provided



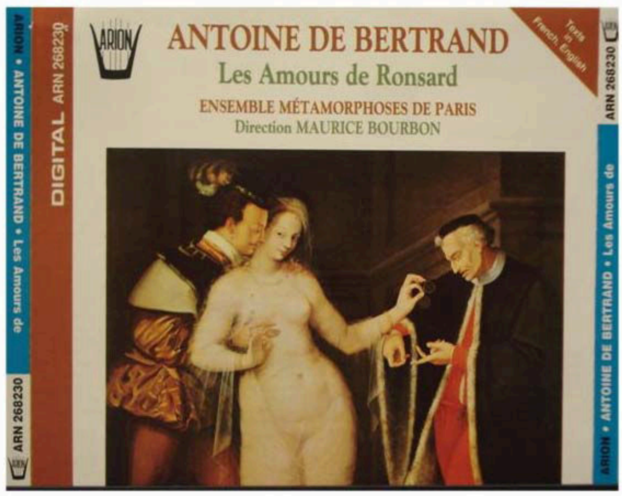


Figure 4.14: example of resources "discovered" in the museum archives, providing scenario ideas for the application content.

Once the themes were available, the work with the physical archive started. All available material was consulted and commented regarding suitability to the selected public. At first, texts were composed by the museum curator on the basis of a discussion regarding the archive "findings". The author suggested ideas and established lists of material (e.g. documents, photos) for digitization in order to transfer them to the lab where the second phase of content creation would take place. However as time went by, and mutual understanding and trust was built, the author was allowed to play an even more active role in content creation, composing texts and then submitting them to the museum curator. In addition, the Picasso painting greatly benefited from multimedia content, prepared by the museum educators especially for the new AR prototype.

4.8.3 SCENARIO CREATION, NAVIGATION SCHEMES AND CONTENT AUTHORING IN THE LAB

The material prepared was then transferred to the lab where a new authoring process took place. At the beginning the provided by the curator texts were examined, together with the available illustrations in order to obtain some first ideas regarding scenarios of presentation. Should the textual information obtained by the museum be presented as text or as audio? Would a text with images be transformed in a simple slideshow or an "augmented" one? Which were the painting elements to highlight and present in 3D and which ones in 2D?

2D and 3D slideshows were subsequently prepared, additional photographic material was when necessary demanded, while many audio sequences had to be recorded. This process was iterative; as soon as the first scenarios were ready, they were once again submitted to the museum for validation and subsequently transferred for modifications in the lab (Figure 4.15).

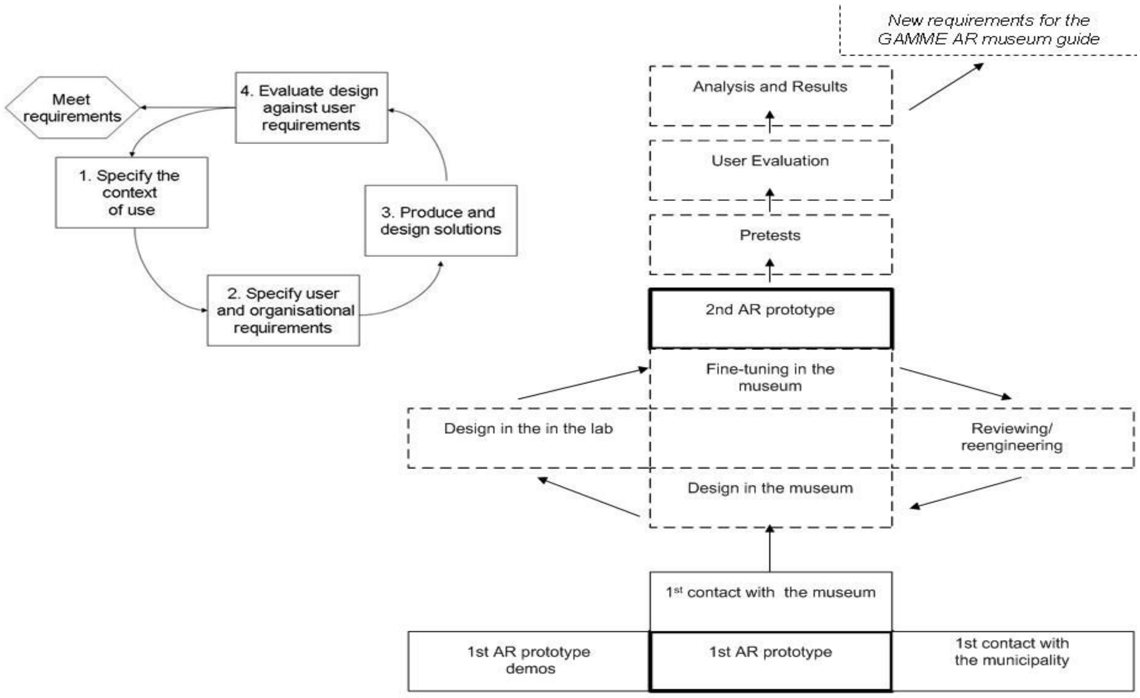


Figure 4.15: To the right, the iterative design process followed and relations between all three AR prototypes, to the left graph of the ISO 13407 (ISO, 1999) standard.

Regarding navigation in the content of the application, one particular design was retained, susceptible to be consistent but also provide "affordances" (Norman, 1990): this navigation scheme used the thematic axes proposed by the museum professional for navigation at a 1st level, and pictograms of the available type of media below each thematic axis, for navigation in a second level. Eventually, at a third level, the visitor would find controls for forwarding or rewinding a multimedia presentation. The different media available in the guide were:

- Simple text: an effort was made to keep texts short and legible on the UMPC screen.

- Audio: parts of text would be recorded so as to provide the visitor with audio comments.

- Video: despite the effort to find several video sequences, only one video was found appropriate enough to be included

- Still images, serving as reference images comparing the work of art with other related works.

- Slideshows: slideshows would be used to "augment" the actual paintings with details or other reference and comparison images, either in 2D or in 3D.

- Animation slideshows, capturing the attention of the visitor in a more entertaining way.

The navigation scheme that resulted from this procedure is illustrated in the mockup presented below in Figure 4.17 and in the scheme of Figure 4.16.One of the first things to be checked out was the visual metaphors that would be used for presenting the content. The first intention was to try to find images that would visually convey the content of each theme. For some of the themes, this seemed possible. For some other however, as the "iconography" theme or the "technique" theme, this proved to be much more difficult. The result was not judged satisfactory. The icons were therefore replaced by 3D ovals with inlayed text. Representing the available media, below each theme, was an easier task. Icons that make allusion to audio, video, text or slideshow are far easier to understand by a wide public. In Figure 4.17, we see a mockup with the different thematic axes available for the anonymous 16th century painting.

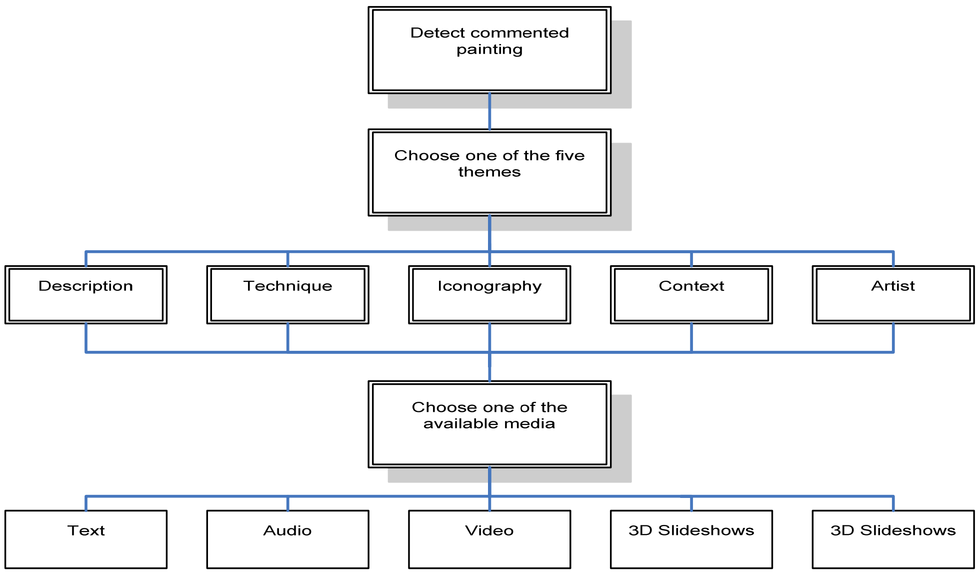


Figure 4.16: Navigation scheme of the mobile AR guide.

When the visitor decides to activate the theme "artist", images corresponding to the nature of the available information will be displayed. In the case of the example below, under the theme artist, there is one audio comment, text, a slideshow and a video (Figure 4.17).

Figure 4.17: Mockup demonstrating the navigation scheme adopted for all paintings

After reviewing and validating the presentation scenarios and preparing all the elementary presentation media (audios, texts, video, slideshows or animated presentations), the actual content authoring had to take place.

As previously seen, in the architecture section (4.7.4), the AR application contains a module that allows the authoring of educational scenarios using XML files. For each painting, a MagicEngineItem.XML file is created (an example is provided in Appendix III). Apart containing information for the pattern to be detected, this XML file provides also a description of all available themes and their corresponding multimedia presentations. The XML file, first defines the 3D objects to be created once the painting is detected, corresponding to the five available themes, "description", "technique", "iconography", "context" and "artist". Then the XML document defines which virtual objects appear when a theme is activated. These objects represent metaphors as to the nature of the available resources and are linked with other XML files containing the type of presentation and its physical address (Appendix III). During all phases of content authoring, several visits in the museum were necessary in order to fine-tune the application and ensure its robustness and its stability.

4.9 A WALKTHROUGH IN THE FINAL AR APPLICATION

The visitor holds the UMPC with both hands and "scans" the surrounding environment, in this case one of the museum galleries exhibiting paintings. The camera with which the UMPC is equipped captures the video of the real scene which is used as a real-time background of the application. The application recognizes the paintings that are commented and annotates them with a question mark pictogram. When the user approaches the commented work of art, an audio alert is heard and a menu appears around the painting, consisting of five 3D objects, each representing one of the five available themes, "description", "technique", "iconography", "context" and "artist" (Figure 4.18). The visitor is provided with the possibility to use a "freeze" button (pause in the application) that will make the camera use the last captured frame as a background. This possibility was provided so that the visitors do not have to constantly point the camera to the paintings, holding the UMPC in an uncomfortable position.

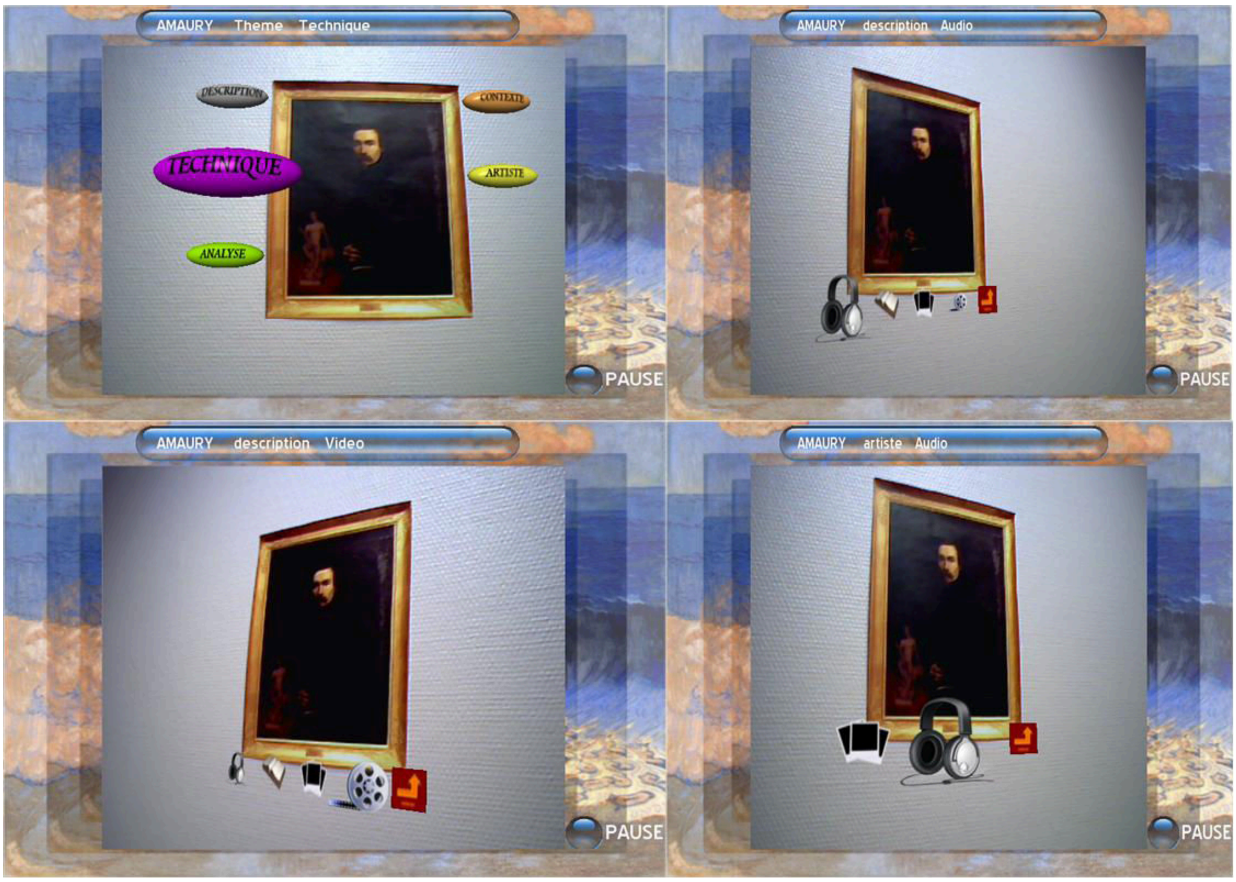


Figure 4.18: Examples of the navigation scheme employed for the paintings

Using the joystick of the UMPC, the visitor can navigate from one theme to another. When one of the five themes is selected, a new menu appears, with the form of images, each representing a medium (audio, text, video or slideshow). A back button for return to the previous level is also provided. The visitor can then activate the desired presentation. All types of presentations can be presented in a series of sequences. The visitor can go forwards and backwards within these sequences using the joystick. When a sequence has ended, the submenu appears once again. The visitor, using the "back" button, can navigate back to the themes level. The navigation scheme and the interface employed for the final prototype is demonstrated in Figure 4.18.

4.9 SUMMARY-CONCLUSIONS

This chapter presented the procedure followed for the design and implementation of two mobile museum guide prototypes based on the AR metaphor and using mobile AR technologies and tools. Both prototypes benefited from the definition of a list of 29 possible functions, further classified in four distinct categories.

The chapter also presented the ways by which the initial prototype, though modest, served in order to approach the local museum and propose a common project and looked into the different stakeholder motivations and needs. The setting of the main study, the Museum of Fine Arts in Rennes, was also presented, before exposing the complex process of content creation in terms of educational scenarios and application authoring. The main components and the architecture of the application were also visited as well as the mechanisms by which the application authoring took place. Finally, the navigation and interaction scheme that resulted both from the process of content creation in the museum premises and the computer lab as well as the resulting application structure was also examined.

The next chapter will particularly focus on methodological issues regarding the evaluation of the AR guide in the museum premises and will also explain the procedure through which the evaluation protocol took shape.

CHAPTER 5

METHODOLOGY FOR EVALUATION AND DATA COLLECTION

5.1 INTRODUCTION

This chapter completes the previous one by describing the way evaluation was planned, set up and carried out in collaboration with all of the involved stakeholders. Though the content of this chapter is substantially a part of the iterative design process, its complexity and importance, regarding the main research hypothesis, implied a separate presentation.

This new section presents the state of the art regarding evaluation for mobile guides in the museum setting and proposes a systematic taxonomy for the evaluation of related projects. The project-specific requirements, resulting from the AR character of the museum guide, are then presented, as well as their impact on the evaluation methodology and the evaluation protocol retained. Based on the proposed evaluation taxonomy, the methodology that shaped the main research questions is presented. The adopted evaluation protocol is then examined, before passing on to the section presenting in detail the task and experimental setup employed for the on-site experimentations.

5.2 EVALUATION FOR MOBILE GUIDES IN THE MUSEUM SETTING

5.2.1 WHY TO EVALUATE

Evaluation regarding the introduction of mobile guides in the museum setting is a concrete issue that has hopefully – and unlike other areas in human computer interaction - been accredited sufficient interest and importance among the related scientific community (Kelly, 2002). The main reasons for that have been already exposed in section 2.5 where human, economical and technological barriers were identified and discussed, but will be briefly reminded here.

The design, implementation and maintenance of a portable multimedia guide are time- and resources-consuming processes. Few "off-the-shelf" solutions exist and therefore museums together with IT companies have to start from scratch in order to create a mobile multimedia guide. An interdisciplinary approach and an iterative design process are therefore needed in which, ideally, information technology specialists, museum curators, educators and visitors should participate. The necessary infrastructure in terms of hardware and software and its maintenance is another issue that raises the cost and the risk of related interventions, and one that calls on early evaluation, though recent experiences have shown that in the future visitors could use their own devices to download the necessary applications (Samis and Pau, 2006).

At the same time, the very nature of the museum, where the exhibitions has long been thought to constitute the major form of pedagogy (Hooper-Greenhill, 1994, Hooper-Greenhill, 2000) makes evaluation and assessment a prerequisite, in order to ensure that the guide and its multimedia content will not be used –as museum professionals often fear (von Lehn and Heath, 2003)- in a distractive, "tv-like" manner, but will indeed help the visitor in making meaningful links between the actual exhibits and the interpretation material with no fragmentation of attention (Aoki et al., 2001). As museums are open to a wide public of different ages, backgrounds and needs, evaluation is also very useful in tailoring not only the content but also its structure and presentation to different museum visitors profiles. Last, but not least, evaluation studies can help IT and museum stakeholders in the establishment of best practice and reference resources for other cultural heritage institutions internationally (Damala and Kockelkorn, 2006).

5.2.2 HOW TO EVALUATE

The mobile human computer interaction community has lately developed a vivid interest for ethnography and ethnomethodology as it becomes more and more apparent that the context of use of mobile devices and services is equally -if not more- important than the device and the proposed applications themselves (Blom et al., 2005, Dourish, 2001, Gonord and Menrath, 2005, Tamminem et al., 2003, Galani, 2005).

As important as this evolution might have proved in other areas of mobile human computer interaction, in our case it might be misleading to further insist on the theoretical background of this approach. Ethnomethodology, psychology, sociology but also market research-theory and approaches have longtime now been integrated in museum studies, and visitor studies more in particular (Hooper-Greenhill, 1994). It would therefore be no exaggeration to suggest that museum professionals could teach a great deal to their IT stakeholders if they were aware of the potential of reshaping already existing knowledge from visitor studies and museum learning theories (Damala, 2007b). This remark is also very clearly illustrated in Figure 5.1, which presents side by side a model of the ISO 13407 standard (ISO, 1999) and a graph representing the three main phases of museum-exhibition development (design phase, implementation phase and development phase) (Grewcock, 2002).

Evaluation activities related with the introduction of multimedia and interactive applications created for museum documentation or interpretation purposes can also be considered to exercise an influence on the methods used for the evaluation of mobile museum guides (Economou, 1998, Economou, 1999). Finally influences can also be detected in evaluation practices and guidelines employed in the field of computer supported learning and in the field of interaction with mobile devices and services (Nielsen et al., 2006, Been-Lirn Duh et al., 2006, Love, 2005).

5.2.3 WHEN TO EVALUATE

Three main types of evaluation can be distinguished: front-end evaluation that occurs during the very early stages of a multimedia project, formative evaluation, that takes place during the development and production of a project, and finally summative evaluation that follows the completion of a project (Frechtling-Westat et al., 2002). With regards to the creation of mobile multimedia museum guides, summative evaluation is conducted in the majority of projects' evaluation (Table 5.1).

5.2.4 EVALUATION METHODS

Once an evaluation type is chosen, the appropriate methodology needs to be selected. Two main approaches can be distinguished: qualitative evaluation methods and quantitative evaluation methods. Qualitative and quantitative evaluation methods have different strengths and weaknesses that one should take under consideration before choosing which methods are best suited for the purpose. Questionnaires, surveys, tests and data logs make part of quantitative evaluation methods, while interviews, focus groups, observation, tests and the use of visitors' impression book belong to qualitative evaluation methods. However, it is important to keep in mind that in reality all forms of data gathering may result in qualitative or quantitative results (Preece et al., 2007).

Surveys and questionnaires are good for gathering descriptive data, are relatively inexpensive and can be analyzed using a variety of software. They can provide a good general picture but they usually lack depth. Interviews can yield a richest and more in depth data but they are time consuming and difficult to transcribe and analyze (Frechtling-Westat et al., 2002). Focus groups are good for generating new ideas and for brainstorming sessions as well as for clarifying quantitative findings, even though one of the drawbacks could be that group interaction could be limited or non productive (Kuniavsky, 2003). Observation is suitable for identifying unanticipated outcomes but is expensive and time consuming, needs trained personnel and a good observational coding form (Love, 2005). Tests are thought to be efficient when gathering information on the status of knowledge (or the change in the status of knowledge). Finally, data logs can reveal patterns of behaviour and provide answers to very interesting questions regarding the duration of a visit, visitors' favourite multimedia sequences and adopted navigation schemes (Kuniavsky, 2003).

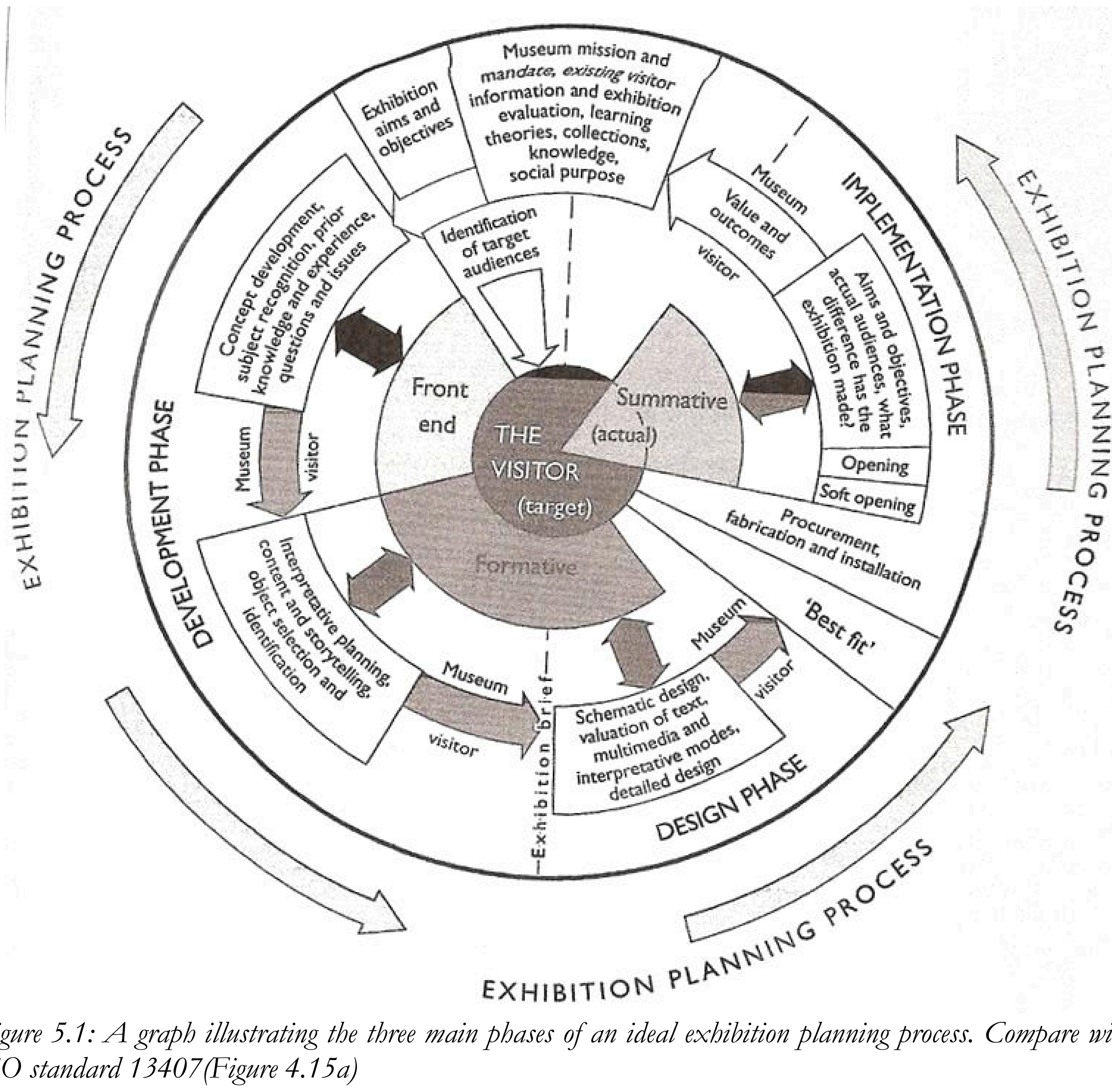


Figure 5.1: A graph illustrating the three main phases of an ideal exhibition planning process. Compare with the ISO standard 13407(Figure 4.15a)

5.2.5 EVALUATION METHODOLOGIES AND ASSESSMENT OF MOBILE MUSEUM GUIDES

How does evaluation take place in the museum, when mobile multimedia guides are put on the benchmark? A thorough literature review was undertaken in order to shed light on the methodologies employed in relevant projects and the research questions related. The findings were first presented in the 3rd AVICOM International Museology Conference in 2006 (Damala and Kockelkorn, 2006b), in the form of a comparative table, reproduced here, in order to facilitate the comparisons regarding the type of the evaluation conducted (front-end, formative, summative), the methods used to collect the data (observation, questionnaires, log files, focus group etc), the evaluation/research questions, as well as the size of the sample.

As we can see in Table 5.1, where some of the most representative evaluated mobile museum guide projects are presented, despite the risks involved in the development of a mobile museum guide, summative evaluation is conducted in the majority of the cases. Mixed-method evaluation sessions are usually conducted though –as expected- qualitative methods seem to be employed when the sample is relatively small and quantitative methods when the sample is large. However it is important to point out that even informal evaluation conducted with a small number of participants may yield interesting results that can at a later phase be used in order to plan more structured and organized evaluation sessions. This is also due to the fact that the niche domain of design and implementation of mobile museum guides is relatively new and so far no exhaustive list of research questions seems to exist (Exploratorium, 2001, Exploratorium, 2005, Damala and Kockelkorn 2006b).

5.2.6 THE NOTION OF EFFECTIVENESS

The various studies conducted so far for the evaluation of mobile, multimedia museum guides, treat several aspects, as diverse as navigation, interaction, usability, ergonomics, learning (Bartneck et al., 2006),user characteristics or localization. The goal in all cases seems to be measuring the effectiveness of applications designed for mobile multimedia museum guides. But what does effectiveness really mean and how many forms can it take?

In the experimentations that took place in the Genoa's Costa Aquarium the goals set were to measure pleasure and usability as well as ease of use, enjoyability, general usefulness, value, fragmentation of attention and knowledge acquisition (Bellotti et al., 2002). In Filoli, an historical house in Woodside, California, evaluation was conducted in order to measure the "attentional balance" in between three different entities, the guidebook, other visiting companions and the exposed object (Aoki et al., 2001). The Muse project implementation for "Il Museo e Certosa di San Martino" in Naples set out as a goal to measure general user satisfaction, the multimedia design content, the ergonomics and the usability of the navigation and the interaction design (Galasso et al., 2004).

Table 5.1: Comparative table of evaluation methodologies applied on mobile museum guide projects

Evaluation Methodology ► Project ▼	Evaluation Type	Employed Methods	Evaluation Questions	Sample
Genoa's Costa Aquarium (Bellotti et al., 2002)	Summative Evaluation	Questionnaires Interviews User observation Tests	Enjoyability Usefulness Length of use Distraction Knowledge Acquisition	120
Sotto Voce (Aoki et al., 2001)	Formative Evaluation	Interviews User observation Log files	Distraction Attentional balance Social Interaction	14
The Muse project, Il Museo e Certosa di San Martino (Galasso et al., 2004)	Summative Evaluation	Heuristics Questionnaires	Ergonomics Usability Navigation Interaction design Multimedia design User satisfaction Marketing opportunities	49
Multimedia Tour, Tate Modern (1st phase)	Summative Evaluation	Questionnaires Log files	Length of use Ease of use Content design Interaction Interface design	852
Highlights Tour, Tate Modern (2nd phase) [also BSL tour and Collectios Tour] (Proctor and Burton, 2003, Wilson, 2004).	Summative Evaluation	Focus groups Observation Questionnaires	Length of use/visit Navigation Multimedia Use Navigation Positioning system Messaging system Social Interaction	1569
Dinohunter, Senckenberg Paleontological Museum (Sauer and Goebel, 2003).	Front-end evaluation Formative evaluation	Focus groups Interviews	Usability Interface Navigation Ergonomics	Not communicated
J.Paul Getty Museum, Rembrandt's late religious portraits (Hart, October 2005).	Summative Evaluation	Comment cards Surveys Focus Groups Observation Log files	Usefulness Accessibility Ease of use Interface Contents Navigation Cognitive impact	Over 4000
Electronic Guidebook, Exploratorium (Exploratorium, 2001, Exploratorium, 2005, Hsi, 2002).	Summative Evaluation	Observation Interviews Log files	Content delivery Interaction Isolation Personalization	15
Mobivisit, Museum of Fine Arts, Lyon (Damala et al., 2005)	Summative Evaluation	Observation Interviews Log files	Interface Geolocalization Interaction Navigation	325

In the Marble Museum of Carrara in Italy evaluation was conducted to measure the impact of the quantity and quality of the information provided, the modalities of the content presentation, the interaction with the handheld devices, and the capacity of visitors to orientate themselves in the museum (Ciavarella and Paternò, 2004). One of the most extensive evaluation efforts has been carried out by Tate Modern, in London; the goal was to validate the content design and the modalities of interaction, navigation and interface design as well as to measure the length and ease of use (Proctor and Burton, 2003, Wilson, 2004). Another very extensive evaluation session was conducted by the Jean Paul Getty Museum, which implemented a mobile guide on the occasion of the temporary exhibition of Rembrandt's late religious portraits (Hart, October 2005). The results were published in October 2005 and were relevant with usefulness, accessibility, ease of use, interface, content quality and navigation. The sample consisted of more than 4000 visitors. The Exploratorium, a popular science museum in San Francisco, USA that has been one of the first institutions to experiment with mobile, multimedia guides has also released studies concerning the use of mobile handheld devices in the museum premises and has already organized two forums on that subject (Exploratorium, 2001, Exploratorium, 2005, Hsi, 2002). The Dinohunter suite, implemented for the Senckenberg Paleontological Museum in Frankfurt, evaluated the usability, the interface, the navigation and ergonomics of the proposed mobile application (Sauer and Goebel, 2003). For the last project examined, the Mobivisit guide that was implemented for the Museum of Fine Arts in Lyon, evaluation examined aspects such as interface, geolocalization, interaction, navigation and content structure (Damala et al., 2005).

5.2.7 A TAXONOMY FOR THE EVALUATION OF MOBILE MUSEUM GUIDES

Still, as we can also see from the table, it is very difficult to establish a taxonomy for the evaluation points that would be candidate to be assessed in related projects. It is for this reason that, while planning the evaluation sessions to be conducted in the Museon museum, in the Netherlands (section 2.4), an effort was undertaken to establish a taxonomy grill of common evaluation issues appearing in every mobile museum guide project, as part of the PhD research project undertaken by the author.

This first proposed taxonomy was presented during the Mobile HCI Conference that took place in 2006 in Finland (Damala and Kockelkorn, 2006b). The main points of this contribution were the following. First that in the case of mobile museum guide projects, evaluation needs to be conducted not only with the main target group of the application, meaning museum visitors, but also with all the staff involved in the creation, implementation, design and distribution of a mobile multimedia guide, namely museum and IT professionals. The second contribution was the distinction of three categories under which evaluation points can be grouped: technological evaluation points, information impact evaluation points and logistics/administration evaluation points. The third point comes as a consequence of the first two, implying that all three types of evaluation points can be examined from the point of view of museum visitors, museum professionals and IT companies. Let's now have a closer look at the three categories of evaluation key points (Table 5.2).

Table 5.2: The initial evaluation points classification grid

	TECHNOLOGY	**INFORMATION IMPACT**	**LOGISTICS/ADMINISTRATION**
MUSEUM/ IT PARTNERS	Content implementation Geolocalisation Content delivery	Content creation Users Groups/profiles	Maintainability Business aspects Number of devices Training of personnel
MUSEUM VISITORS	Usability User interface Recovery Personalization Ergonomics Positioning system Messaging system Ease of use Accessibility	Content quality Relationship with exhibition Orientation Learning/knowledge Enjoyability Distraction Attentional balance Social interaction (isolation) Usability Interaction impact User satisfaction Usefulness	Distribution Registration process

Technology-related evaluation points are strongly linked with choices made regarding the actual software and hardware used to design, implement, and deliver multimedia applications for museum handheld guides. In this case, evaluation with museum staff should include evaluation questions relevant with the content implementation, the effectiveness of the chosen way for content distribution (either remotely or locally stored), the geolocalization modules, in case they exist to help with visitors' orientation and, finally, the content delivery and adaptation to potentially different platforms and available bandwidths. Technological evaluation points must also be assessed with museum visitors. Under this category the issues classified were the usability and ease of use of a proposed application, the overall user interface, including navigation, multimedia and interaction design, the recovery of the system after a potential crash, personalization, ergonomics (such as the use of stripes or headphones), the positioning and messaging system and the system's accessibility.

Information impact evaluation points are relevant with the impact of introducing a mobile multimedia guide in the museum environment. From the museum's point of view the choice of the technology, mentioned above, is very much related with the process of content creation and content update as well as with the creation of user groups and profiles. Information Impact evaluation points are more numerous when examining the visitors' side. Here, one of the main evaluation points is the content quality, structure and design, standalone as well as in relation to the exhibition. Usability, enjoyability, usefulness and user satisfaction is another group of points often examined in evaluation sessions. Distraction and attentional balance as described by Aoki et al. (Aoki et al., 2001) falls under this category as well as learning, knowledge acquisition and visitors' isolation.

Finally the third category groups evaluation points relevant with administration/logistics issues. Regarding the museum professionals, evaluation needs to be conducted in relation to maintainability. Maintainability covers aspects such as battery life and recharging, updating older versions of the multimedia applications, security, not only of the devices but of the overall museum information system, as well as distribution and recovery of the terminals after the end of each session. Other important issues to examine are the number of devices or terminals needed as well as the number of employees needed to handle the distribution and the recovery of the devices. Distribution and registration process needs also to be evaluated with visitors in order to see if the full process of getting and using a mobile device is smooth and not time- and energy-consuming.

5.2.8 THE EVALUATION TAXONOMY REVISITED

Despite of the concrete usefulness of this first taxonomy approach, put on paper during the DANAE project in order to plan the evaluation session that would follow before the project completion, it soon became obvious that certain ameliorations could be made to this scheme as to its essence and the employed onomatology

The first important modification that renders the taxonomy itself easier to understand and use is related with the 2nd category that was renamed "Interactive Content" (instead of "Information Impact"). This name makes more sense, as it distinguishes more clearly the difference between evaluation issues related with the technologies used for the design, implementation and delivery of the application and the actual interactive content evaluated. The name of the other two categories remained the same.

Another important differentiation is related with the involved stakeholders. A new category was added to the already existing three categories, museum visitors, museum professionals and IT stakeholders. The new category caters for the role of sponsors often enough involved in related projects. For example, Bloomberg has been the sponsor for the Tate Modern Multimedia Tour in

London (on site visit, July 27, 2008), and Korean Air, the main sponsor of the new multimedia guide of the Louvre (Louvre, 2008). Further on, as it is easy to understand by viewing the new taxonomy (Table 5.4), the effort to link stakeholders with particular evaluation points/or issues was dropped, as the majority of the identified evaluation issues can be matched with one of the four related stakeholders, depending on the nature of each mobile museum guide project.

Finally, all evaluation issues/points, of all three categories have been reviewed and most importantly enriched with new issues identified. Though a major effort was made to place evaluation issues only under the most corresponding category, sometimes this task is very hard if not impossible to achieve. For example usability, can be examined under several aspects, such as the content creation or the content update and the interactive content delivered to the visitors, but can also be related with the logistics/administration process, if we seek to explore how easily the museum personnel charged with the distribution of the guide, can accomplish the tasks of handling and distributing the devices.

In order to resume the proposed taxonomy after its reformation and enrichment, and before moving forward in examining project-specific issues that influenced the evaluation methodology, let's just sum up the most important facts as to the proposed scheme:

Three categories of evaluation issues are more than susceptible to arise during a mobile museum guide evaluation process, be it front-end, formative or summative: The first category is related with the technologies chosen for the implementation of the guide. They embrace various aspects ranging from the capacities of the platform chosen for the delivery, to the application and content implementation: Who develops the application? Does this person have to be specialized? How the actual content is created and how long does that take? Can this task be performed by museum professionals or will they need assistance? How robust the different components of the guide to be manipulated are? How is the content updated? This first category is more related with museum and IT professionals but the answers could be of importance for a potential sponsor, while they have a serious impact on the other two categories.

The 2nd category, renamed "Interactive Content" groups issues that should be mainly evaluated with museum visitors, though front-end evaluation with museum and IT professionals would also make sense. As the name implies the evaluation issues here are relevant with the actual content delivered, its quality, its duration, the ease of use, but also the way it is actually used by visitors when they try to get some insights about exposed objects, while moving and trying to navigate and orientate themselves in the museum space and in the mobile, accompanying, multimedia application.

Finally, the 3rd category groups evaluation issues related with logistics and administration aspects. Who distributes the devices? Will they be given free of charge or will there be a fee? Does the visitor have to leave a deposit? How robust are the devices? Which is the duration of the battery life? Do devices need to be maintained and how often? What is the interrelation with other IT applications used in the museum? Does the existing infrastructure satisfy the application requirements? All issues of all three categories are listed in Table 5.4, proposing a pool for forming evaluation and/or research questions.

5.3 PLANNING THE AR GUIDE EVALUATION

In the previous section, we examined several issues related with the use and evaluation of mobile multimedia guides in the museum setting and demonstrated the underlying relations with other disciplines, while introducing a taxonomy of evaluation issues susceptible to arise when evaluating mobile museum guidance systems. However, there exists another important parameter that had to be taken under account for the experimentations: benchmarking the research hypothesis that AR could be used as a principal component for the design and the implementation of an interactive mobile multimedia museum guide. Seen under this perspective, the application to be evaluated falls not only under the category of mobile museum guides applications but also under the category of mobile AR applications.

5.3.1 AR RELATED METHODOLOGICAL CONSIDERATIONS

Though AR has been studied for nearly four decades now, it is only recently that research started to focus more on evaluation and HCI issues (Dunser et al., 2008, Swan and Gabbard, 2005, Dunser et al., 2007, Grasset et al., 2007b). It is probably for this reason that AR has been characterized as being “technology-driven”(Anastassova et al., 2007b, Dunser et al., 2007), and AR systems as being “technology-centric” (Swan and Gabbard, 2005).

One of the main reasons for that is that AR is an emerging technology (Anastassova et al., 2007a, Anastassova et al., 2007b, Gabbard and Swan, 2008, Haller et al., 2007), and as such, does not boast established design guidelines, heuristics or fixed and well accepted interaction metaphors. This last remark is also due to the fact that AR has not yet defined specific or standardized interfaces (Dunser et al., 2007, Wagner, 2007). Some researchers even doubt about whether this will ever be done, due to the variety of the devices and interfaces used for Augmented Reality applications (Bowman et al., 2005, Dunser et al., 2007). It is illustrative that up till today, none of the already proposed AR systems has made a huge market success (Wagner, 2007).

The lack of design guidelines and standardized dedicated delivery-platforms is not the only problematic issue in the domain of AR technologies. As we already saw in chapter 3, AR suffers also from the lack of dedicated advanced authoring tools not only for tracking and pose estimation but also for content creation (Haller et al., 2007). This fact forces developers and engineers to spend considerable amounts of time in creating a single version of an experience that cannot be evaluated until all technology is put in place, an appropriate and robust platform is selected and content is authored (Dunser et al., 2007). The rapid prototyping and the iterative design process employed in other disciplines of software and interaction design is thus prohibited (Gandy et al., 2007). On the other hand, it has been argued that when low- or mid-fidelity AR prototypes are used for evaluation purposes, end-users risk to underperform (Anastassova et al., 2007a).

Hopefully, these deadlocks have recently started to draw the attention among the HCI and AR communities. Two publications are of particular interest and will be briefly commented here in chronological order, as they provide an overview of past and current practices regarding the field of AR, evaluation and human centered design. The 1st study was published in 2005 by Swan and Gabbard (Swan and Gabbard, 2005). These two researchers examined a representative sample of 266 publications related with AR, published between 1998 and 2004. By reviewing this filtered pool of articles, they found out that only 38 (~14%) addressed some issue of HCI and only 21 (~8%) described a formal user-based study. The 2nd study was published in September 2008 by HITLab in New Zealand (Dunser et al., 2008). Among 557 AR related publications published between 1993 and 2007, only an estimated 10% was found to include some type of user evaluation.

These percentages are rather illustrative as to the state of the art in evaluating AR technologies and applications. They also partially explain why the end-user is most of the times integrated at the very last stages of a project (Dunser et al., 2007). However, other reasons have also been identified, such as incorrect motivations for proposing AR applications (Dunser et al., 2008), the lack of education on how to evaluate AR experiences, or the lack of understanding of the need for conducting evaluation. It is therefore not surprising that even in the context of more popular - than the museum environment- AR-specific domains (such as industry or assemblage), actual empirical results do not consistently report on the benefits of using AR over more traditional job aids (Anastassova et al., 2007a).

But other reasons can also be identified. As we also had the possibility to experience during the early stages of the design of the AR guide for the museum of Fine Arts in Rennes, even when the end-users and other stakeholders are early enough implicated in the design process, they demonstrate difficulties in expressing their needs in terms of AR scenarios (Damala et al., 2008), or are barely aware of potential applications (Anastassova et al., 2007b) as the term AR is far from being widely used. This fact has led some researchers in employing the term "ill-defined" for the description of the process of user task-analysis in AR applications (Anastassova et al., 2007b, Haller et al., 2007, Sandor and Klinker, 2007).

All these issues have been so far resulting in a vicious circle, which risks prohibiting the adoption of AR applications in the long term. In an article of 2002, treating usability engineering with regards to AR, Gabbard and Swan (Gabbard et al., 2002) stress out that usability in AR applications is as important as in any other kind of interactive systems and that in order to attribute to a system high usability, the latter has to be both useful and usable. Some AR experimentations however have so far demonstrated some limitations regarding either the first or the second attribute. Giving the possibility to a person to remotely caress a hen equipped with a special jacket (Lee et al., 2006) might present several challenges as a potential application technologically speaking, but risks to raise questions as to whether the application is useful or not. On the other hand, visiting an archeological site equipped with a wearable AR system that superimposes reconstructions of ruined temples is quite useful (Sforza et al., 2001, Gleue and Daehne, 2001, Vlahakis et al., 2002) but not usable if the equipment is bulky and heavy, the user has to wear a head mounted display and the external temperature under shadow exceeds the 38° C degrees. In both examples, it is not the technological achievements that are put under question but their degree of usability.

5.3.2 CURRENT PRACTICES IN AR EVALUATION

Some of the major reasons for the underutilization of evaluation regarding AR applications are now more understandable and have been exposed. Underutilized or not, it would be useful to examine tendencies in the evaluation of AR applications, in order to spot possible research future directions. Three articles are of particular interest, as they provide an overview of evaluation techniques and methods in AR.

The first paper examined is (Anastassova et al., 2007a). Anastassova examined 48 articles related with user-centered design and evaluation in AR industrial applications. The criteria the articles had to meet in order to be included in the survey were to treat an aspect of human-centered design and to include empirical results. The fact of examining and publishing in the same study articles that employ user needs and task analysis as well as usability evaluations seems to be due to the fact that only a small number of AR research studies treat user-centered design principles and evaluation issues. Anastassova reported that the majority of the articles (83%) treated usability issues and only 8 (~17%) presented user needs-analysis. She also found out that in this last category the goal is usually to address "conscious" user needs (~63%) rather than "unconscious" ones. In terms of methodology, she affirms that the studies aiming to examine already specific needs use mainly interviews with task experts, quick field analysis of future users activity and questionnaires, while the studies aiming to shed light on unclear user requirements are mostly based on prototypes and scenarios' evaluation. As to the articles dealing with usability evaluation, which represent the greater percentage (83%), the goal most of the times is to evaluate the ease of use of AR interfaces and their effectiveness for training, though the latter appears less often than the former. The number of participants in the examined experimentations ranged from 1 to 75, with the average being 15. Another very important remark is that usually the experimental tasks are "artificial, simple and of short duration" and only 18% of the studies that were reviewed tried to place the potential users in a real-conditions experimental setting. Anastassova concludes that there is clearly "a lack of structured methodology to analyze user needs and to evaluate existing technological solutions" and points out that user needs-analysis is "a challenge for emerging technologies…because innovation is upcoming and in search of potential applications" (Anastassova et al., 2007b).

The need for the employment of user-based studies regarding the creation of AR applications and interactive experiences was also underlined by Gabbard and Swan in a recent, posterior to our experimentations article, published in May 2008 (Gabbard and Swan, 2008). The authors stress out from the very beginning that user-based studies can provide valuable insight for emerging technologies, fundamentally altering the way humans perceive the world, such as AR. They also claim that the integration of usability engineering and user-based studies in the AR research agenda qualifies not only as an important challenge but also as a research opportunity.

Gabbard and Swan have also proposed a scheme for the classification of user-based experimentations related with AR (Gabbard et al., 2002). They distinguished three, complementary, axes.

1. User based studies related with issues of human perception in AR (e.g. depth perception, hand-eye coordination and speed of task performance).

2. User based studies related with task performance within specific AR application domains (e.g. target finding, time to task-completion, number of task errors)
3. User based studies related with AR collaborative environments and computer-supportive cooperative work.

Despite the fact that the authors describe these axes as complementary, if we try to place the experimentation of the Museum of Fine Arts in Rennes in this scheme, we will see that it can very difficultly fit in any of these categories. The proposed prototype does not have (at least for the time being) a collaborative character while the first research axis is not applicable in the context of an interactive museum experience. And though the mobile AR enabled guide is closer to the 2nd axis, hardly any of the tasks proposed to the museum visitor is measurable in terms of task-errors or task completion time.

Wanting to cure this gap, Dunser et al. (Dunser et al., 2008), recently (September 2008) proposed an extension by adding a 4th category, that they named "AR interfaces or system usability studies", by precising that these studies "don't necessarily involve measurement of user task performances but other ways of identifying issues with system usability". This 4th category provides a more suitable framework for the type of experimentations that would be conducted in the case of our museum guide. It is important to notice at this point, that from the 161 articles classified in this study, 25,4% falls in this 4th axis but only 8% (13 articles) present formal user evaluations.

This finding is also reflected on a series of other papers, not reviewed by this survey, but by the author, due to the relevance of the domain context, enlarged to include not only museum or art installations but also edutainment applications related with AR. The "invisible train" project is said to have received between 5.000 and 6.000 visitors (Wagner, 2007). However, the results reported were quite poor, as no formal evaluation, even with a smaller sample, was foreseen. During one of the last phases of the ARCHEOGUIDE project (section 3.6.3) approximately 200 visitors tested the AR archeological guide at the site of ancient Olympia in Greece. The reported results were interesting but it is not certain that there were also representative, as no quantification even of qualitative findings was presented (Vlahakis et al., 2005). The Black Magic kiosk featuring an AR book was installed in an exhibition in New Zealand, visited by more than 400.000 people over six months (Woods et al., 2004). Again, the researchers gained some valuable insight they combined with other similar experiences regarding augmented objects in the museum setting, but the informal way of collecting the data makes generalizations very difficult.

Finally, apart proposing a 4th research axis for AR evaluation and user-based studies, Dunser et al. (Dunser et al., 2008) also proposed a taxonomy according to the evaluation methodology employed. Five categories have been distinguished:

1. Objective measurements, where measures should be interpreted with the strict sense of the term (e.g. task completion time, accuracy, error rates).
2. Subjective measurements, or perceived user ratings, usually gathered by the use of questionnaires
3. Qualitative analysis, which includes formal user observations, formal interviews or classification or coding of user behavior (e.g. speech or gesture coding)
4. Usability evaluation techniques, that employ expert based evaluation, task analysis, heuristics or the "think aloud" method.
5. Informal evaluations, including observation or other types of informal collection or feedback.

However, one of the problems of this taxonomy, as the authors themselves have admitted, is that researchers often use a wide variety of methods. In addition, to our opinion, the lines cannot be easily drawn among all of the five proposed categories. For example, in which category should one place an informal evaluation based on observation that is video recorded and a posteriori analyzed and in which participants have been encouraged to use the "think-aloud" method? We believe, that for the needs of our study, the "traditional" differentiation between qualitative and quantitative methods as already analyzed in section 5.2.4 is sufficient.

To conclude, though the literature related with AR applications and experiences evaluation is still not very rich, the research community seems to become more and more aware of the need for evaluation and user-based studies. When evaluation is carried out, it is more often effectuated at an advanced stage (formative evaluation), more often in the laboratory than in the real context of use, and usually for simple or short duration tasks. Evaluation in the real application domain environment is rarer as well as user needs-analysis, most usually carried out with domain experts. Also, it seems that there also exists a paradox, with more evaluation studies for AR either focusing on the use of "objective measurements", difficult if not impossible to apply in the context of the museum visit, or when this is not applicable (like for example in edutainment applications) towards informal experimentation and evaluation. Consequently, and especially regarding AR for edutainment and culture, the blurred and troubled scenery concerning design guidelines is even more uncertain.

5.3.3 EMERGING AR SPECIFIC GUIDELINES

Given the current state of the art regarding evaluation in the AR domain, it could be interesting to try to resume and briefly present some results and suggestions that -though still fragmentary- present good chances for turning into AR specific guidelines. As with the previous section, this presentation will also be of use regarding current limitations and gaps regarding HCI in AR applications, which has only fragmentarily been explored in the AR context (Dunser et al., 2007).

The first question that arises when talking about guidelines for AR systems is whether general GUI guidelines can be applied to AR systems. Dunser et al. suggest that the problem with this approach is that GUI evaluation guidelines take most of the times as a prerequisite an interaction with a screen, a mouse and a keyboard, while AR proposes several other diverse means for interaction (input and output) with an application (Dunser and Hornecker, 2007). The same team of researchers suggested as a direction the use of knowledge derived by VR, which in comparison with AR has been so far more focused on evaluation (Roussou, 2004, Roussou, 2008). As in contrast with this statement, we believe that as with GUI, Virtual Reality is radically different in nature from AR, as in the former the user is completely emerged in an artificial, 3D environment. Of course this affirmation cannot be but depending on the initial definition somebody attributes to Virtual Reality. If for example the definition is flexible enough to include environments such as Second Life, then indeed, some existing guidelines might also be applicable in AR applications.

As we already saw in section 5.3.1, Gabbard et al (Gabbard et al., 2002) discussed the issue of usability and usability engineering for AR systems. For them a product with high usability has to be both useful and usable. They also went further by defining that as with other interactive applications, usability embraces several user oriented characteristics, among which the more important are:

- Ease of Learning
- Speed of User Task performance
- User Error Rate
- Subjective User Satisfaction
- User Retention Over Time

They also insist on the role of domain analysis for AR applications, prior to the beginning of a project, defined as an activity that seeks to explore who are the users and the tasks they will perform. This, of course, comes in vivid contrast with a tendency that sometimes wants engineers to develop new technologies and AR prototypes without having in mind the solution of a particular problem and trying only a posteriori to discover interesting showcases for a particular "invention" (Dunser et al., 2007).

As to the application of general HCI guidelines, there are still many major gaps in the domain and very few contributions. Dunser et al (Dunser et al., 2007) distinguish the following general guidelines as applicable in the AR context:

1. Affordance: Affordance is a term coined by Donald Norman in his book "The Design of Everyday Things" and since then very widely employed (Norman, 1990). It refers to the connection between an interface and its physical and functional characteristics.
2. Reducing Cognitive Overhead: This characteristic is closely linked with the previous as, if a system provides affordance, the cognitive overhead needed to interact with the application will be low.
3. Low physical effort: The user should be able to accomplish a task with a minimum of interaction steps.
4. Learnability: The user should be able to learn how to use the system easily. For this reason consistency is of great importance.
5. User Satisfaction: As the usability of a system does not only rely on objective measurements, it is important to monitor users' satisfaction by using a system.
6. Flexibility of Use: AR designers should be aware of different user preferences and abilities. In the context of mobile museum guides a more appropriate name for this guideline is customization/personalization.
7. Responsiveness/Feedback and Error Tolerance: Users can only take a certain amount of uncertainty as to the condition of a running application. As one of the major problems that AR faces is pose estimation and tracking, experiences should be designed so that poor tracking performance does not interfere with the experience. In the case of the museum particularly, the performance of an application might be influenced by poor lightening conditions or reflections on glossy objects or reflective, transparent, showcases.

The authors conclude by recognizing that this is an "initial attempt to fill the gap that exists in the area" and that there is "too little knowledge about AR systems design to generate generic rules". They also insist that multidisciplinary research is welcome as it might allow the combination of different viewpoints from different areas of expertise, not necessarily from the engineering or "hard" sciences circle (Dunser et al., 2008).

The article of Gabbard et al. (Gabbard et al., 2002) nicely complements this initial list of general HCI guidelines susceptible to be applicable in AR applications. In their article regarding usability engineering and AR, they discuss as common usability problems:

1. A functionality that is missing
2. Poor user performance on a critical or common task
3. Catastrophic User Error
4. Low user satisfaction
5. Low user adoption of a new system (users susceptible not to use a system again because they found difficulties in using it).

Another issue that has been explored is the effect of the use of prototypes for the engineering of AR applications (Anastassova, 2006, Anastassova et al., 2007a, Anastassova et al., 2007b). The main advantage seem to be that their concreteness facilitates discussions about the elicitation of future needs and –eventually- alternative designs, as potential users are usually not aware of the features/functions they can expect from innovative products and applications. However, several disadvantages have also been spotted. The 1st one, is that prototypes have limitations as there are usually differences between the prototype proposed and the final application (Liu and Khooshabeh, 2003). It has also been argued that prototypes usually project engineers' point of view and aspirations and inhibit this way other stakeholder's imagination (Anastassova et al., 2007b). Finally, low-fidelity prototypes might be stigmatized as less efficient, make users underperform or even get rejected because of their immaturity (Anastassova, 2006). For all of the above reasons, Anastassova tried to explore the impact from the use of low-fidelity prototypes in comparison with high-fidelity prototypes in the case of AR applications. A comparative study she undertook led her to the conclusions that users express their need more easily and in a more illustrative way when working with high-fidelity prototypes and that they also seem to be more motivated. She also underlined the importance of conducting experiments in a real work/domain setting (Anastassova et al., 2007b). The importance of conducting AR experimentations in real environments has also been recently discussed by Gabbard and Swan (Gabbard and Swan, 2008).

Finally some very interesting design guidelines, particularly concerning the use of AR for art were provided by Grasset et al. (Grasset et al., 2007c). Focusing on the use of AR in art settings and the collaboration of engineers with artists they described in a very accurate way the process that needs to take place before engineers, artists or museum curators can really discuss about common projects. With their own words, the design process is *"partly dependant on the technical understanding of the artist, which ranges from identifying a technology, appreciating the role of technology, understand how the* *technology works, ability to apply that technological concept in design phase, ability to develop/create content and other work around the technology, ability to use that technology to develop/create what has been designed, through to being able to create new technology themselves."* Of course a similar process has to occur from the side of the interaction designers and engineers collaborating in this rich in cultural connotations projects. For the same reasons, they advice engineers and interaction designers to demonstrate early enough to other stakeholders (artists, museum curators etc) the limitations of the technology to be employed, be attentive to the latter's needs and try to set prioritized design concerns applicable to the common project. Finally, they conclude, that given the risks and hazards of working with new technologies, particular consideration should always be paid on whether the chosen technology is indeed the most suitable for the project.

From this short overview we can understand that evaluation is a very recent research concerning AR. It is therefore understandable that other important factors such as the affective experience while using AR systems have yet to be explored (Bickmore and Picard, 2000, Dierking, 2005, Zhang and Li, 2005). This is only one of the issues we will try to examine during the experimentations in the museum of Fine Arts in Rennes, despite the limited scale of the evaluation session. And even though researchers in the AR community are still obliged for the time being to often follow an "error–fix" explorative approach, as the field evolves, contributions will start to form informal design guidelines that will then more widely be adopted by the scientific community(Gabbard and Swan, 2008). In this context, the permission to experiment with real visitors, in the context of a real museum, trying out an AR enabled multimedia museum guide, presents inherent interest not only for the final results obtained (presented in Chapter 6), but also for the suitability of the methodology followed, the protocol retained and the overall planning of the evaluation session in a real working environment.

5.3.4 PROJECT SPECIFIC METHODOLOGICAL CONSIDERATIONS

The identification and classification of the above mentioned issues was of great help during the planning of the Museum of Fine Arts in Rennes experimentations. However, the particularities of our case study, shaped at a great part the methodology proposed, and then employed. The goal of this section is to identify all these factors and explain the way they influenced the experimentation process.

The first important element is that our experiment was based on the initial hypothesis that a mobile museum guide using AR technologies and consequently the AR metaphor could facilitate museum visitors with orientation, navigation and interaction in the museum space and the multimedia application (Damala, 2008). However mobile museum guides are still far from being the norm among museum proposed interpretation media. In the city of Rennes, none of the museums or historical sites offers such a possibility. Our collaborating museum also had no prior knowledge relative with the use of such devices in an exhibition space. It was therefore normal to assume that the sample that would be recruited would also have no experience on such guides.

Therefore, formulating a research question seeking to answer in an absolute manner whether the integration of AR in a mobile museum guide confirms the initial hypothesis, as in comparison with "traditional" mobile museum guides was ruled out. In addition, even if we admitted that such a prior experience existed, the AR aspect of the guide would not have an autonomous existence, from the moment it was integrated in a mobile multimedia guide implemented to be used in the museum space. For museum professionals, AR or not AR enabled, the introduction of mobile guides in the museum was an issue that needed an impact investigation per se, treating important aspects, such as attentional balance and user distraction. Therefore, professional deontology implied a holistic approach in the evaluation that would not only seek to examine the impact from the introduction of the AR metaphor and the related technologies, but also the way the guide was actually used in the museum.

A second very serious problem as to the methodology to be employed was related with the technology embarked in the guide for the experimentation. The term itself, is not widely spread among occasional IT users, and it was only logic to expect that despite the profiling of the target group, the majority of the recruited participants would not be familiar with the term AR. This was also found to be true with our museum partners. Therefore specific attention should be given to the evaluation protocol and the formulation of the research questions that would be addressed to the selected sample.

Finally, a third difficulty came from the fact that the Museum had never before conducted a formative evaluation process, so despite the museum stakeholders' will to actively participate in formulating the research questions, the research methodology and the evaluation protocol, it was not possible to draw on methods or results from former experimentations that might facilitate the overall appraisal of the role of the guide in the permanent exhibition. For this reason all evaluation phases, from defining the research questions, to proposing a methodology, laying down the evaluation protocol and analyzing the results was entirely confided to the author.

5.3.5 THE RESEARCH QUESTIONS

The first important step to take was to define the research questions that would be explored throughout the evaluation phase. As we already saw above, the cross-disciplinary and collaborative character of the project and the strong implication of the museum professionals in the experimentations implied an overall assessment of the proposed interpretation medium, larger than the mere mobile AR character of the multimedia museum guide. However, it was also clear that because of the restrictions in time and the experimental character of the first prototype, not all possible evaluation issues could be investigated. Therefore, a "compromise" should be achieved, ensuring that all project stakeholders would get answers in the most prominent for them questions.

In order to achieve this, the taxonomy proposed in Table 5.4 was used. Using the table, it soon became obvious that the issues to be investigated were instances of the 2nd column, the "Interactive Content" category. Further on, admitting that the use of AR technologies for the design and implementation of the guide was a concrete issue, a link was established between all evaluation issues and the probability to shed light on the AR aspect of the proposed guide. A new table was dressed, in which each topic was correlated with the AR character of the guide and appointed an adjective, "strong", "medium" or "weak", as to the last (Table 5.3).

Consequently two main group of evaluation issues emerged: AR-related evaluation issues and non-AR related issues.

The first group, of primary importance for the acceptance of the AR guide, included the following research questions:

- Does AR facilitate the orientation and navigation in the museum space and the identification of the commented museum objects?
- Does the AR metaphor facilitate the navigation in the interactive content of the guide?
- Is the way the AR metaphor is used intuitive and easy to understand even by non experienced IT users?
- Is it possible to investigate further affective reactions related with AR?
- Can new means of interaction with mobile AR applications be identified?
- Are there any conclusions we can draw both from the evaluation process and the data analysis that could be of interest for the AR community and other contexts of use?

Table 5.3: Correlating AR research questions with mobile museum guides' evaluation key points

Evaluation issue	**Bonds with AR proof of concept**
Orientation + Navigation in museum space	strong
Orientation/Navigation in the application	strong
Easy switching from the object to the guide/easy retrieval of information	strong
Ease of use (interface/interactions)	strong
Distraction/Attentional balance	strong
Affective Reactions	strong
Transparency/Affordances/Metaphors (clear feedback to the user)	strong
Usability/Easy or intuitive to use	strong
Relevance with the exhibition/object	medium
Learning/Cognitive impact	medium
Robustness of the application	medium
Enjoyability/Usefulness	medium
General Visitor satisfaction	medium
User Groups/Profiles/Personalization	weak/medium
Content length (text, audio, video, multimedia)	weak
Content quality (text, audio, video, multimedia)	weak
Linking the pre/during/post visit phase	weak

This group of questions was of great importance for the IT stakeholders but was also judged interesting enough by the museum professionals.

The second group of questions, less relevant with the AR character of the application but of great interest for the museum professional, was related with the overall impact of using the guide as well as with general utility and usability aspects. The most important questions of this group were:

- The usefulness and the enjoyability of the application and the general visitor satisfaction
- The impact on the post-visit phase and exploring proofs of learning or cognitive impact
- The issue of visitor distraction and attentional balance
- And finally, preference over specific media

5.3.6 THE EVALUATION PROTOCOL RETAINED

The existing bibliography on mobile museum guides provided useful material regarding evaluation methodologies and issues. However the bibliography did not provide any information on mobile museum guides actively using AR for geolocalization, navigation and orientation while the relevant literature among the mobile AR community was also very limited.

At the same time the available technical means (only one device for the experimentations and the use of an executable under development), and the current state of the art in evaluation regarding AR applications (as exposed in sections 5.3.1 to 5.3.4) dictated an evaluation approach qualitative in nature.

However and despite the fact that other researchers have claimed that "formal approaches such as controlled experiments, structured interviews, and questionnaire surveys presuppose that the questions of interest are already known" (Woodruff et al., 2001), it was though wiser to try to formalise not only the main research questions but also part of the evaluation process. A good argument for adopting this approach was that our sample -comprised of 12 participants- was well stratified as the museum decision was to target young people, between 18 to 23 years old.

Hence, the protocol proposed included mainly qualitative methods, in accordance with the exploratory nature of the study, but also made use of a survey. The participants that would be recruited would be observed by the author. Their sessions would be recorded by an external video camera, and an ARCHOS multimedia player that would record only the interaction with the device. A semi-structured interview would then follow (Appendix V). During the interview, participants would be asked if they are also willing to participate in a focus group session, to be conducted approximately one and a half month after the visit (Appendix VIIIb). If they consented, they would also have to fill in a survey (Appendix VI) prior to the focus group session. Unfortunately, because of the very demanding in terms of resources executable and a certain lack of time, it was decided not to include a log system in order to log all visitors' actions. This inconvenience was partly remediated by the fact that all interactions of the users with the prototype would be captured by the ARCHOS multimedia player by means of a small camera that would be attached to the head of the participants using a headband (Figure 5.3b).

The evaluation protocol as well as the questions to be included in the questionnaire was discussed with all stakeholders prior to release. This intensive, mixed-method evaluation process, combining three qualitative and one quantitative method, also implied that the number of the participants to be observed should be small, as all phases of the evaluation and analysis of the results would be carried out only by the author.

Before the experimentation phase began, two pilot evaluation sessions were held in which one museum educator and one PhD second-year student from the Orange Labs participated. These pilot sessions proved to be very helpful regarding the overall planning of the evaluation but also regarding some last minute "arrangements", like the idea to try to compensate the lack of a dedicated platform by using black adhesive tape to mask and mark the buttons that were to avoid touching, and colourful adhesive pastilles to indicate the two buttons that served in manipulating the application.

5.4 TASK AND EXPERIMENTAL SETUP

5.4.1 INTRODUCTION

This section introduces notions relevant with the experimentation environment, the experimental variables and the experimentation process. The description of the experimental conditions and the setup follows a chronological order with respect to the evaluation protocol proposed for the experimentations.

5.4.2 RECRUITING THE CANDIDATES

As mentioned earlier, it was decided to recruit 12 participants for the experimentations, equally representing both sexes. The Museum of Fine Arts volunteered to act as an intermediate for the recruitment of the participants and contacted two University professors, asking them to pass on the message to their students. The contacted University departments for the recruitment of the participants were The School of Fine Arts in Rennes (Ecole des Beaux Arts de Rennes) and the University Institute of Technology in Social Sciences (Institut Universitaire de Technologie - I.U.T.). The common characteristic among all students was the age, while –hypothetically- the profile difference lied in the fact that the 1st group of students was susceptible to visit museums and galleries more often because of the related field of studies, thus augmenting the chances of possible comparisons in between frequent and occasional museum visitors.

A remuneration or "thank you" gift was foreseen, comprised of a gift voucher provided by Orange Labs and a book of the choice of the participants to be selected in the museum shop. In addition, participants also received a photo of them during the experimentations, as a souvenir of their experience. However, it is important to notice that at the time of the announcement of the experimentations, this element was intentionally not mentioned so as to ensure that the motivation for participating in the experimentations would not ne linked with the remuneration. Finally, before the beginning of the experimentations all participants were contacted by phone. The scope and the goals of the study were briefly presented to them while a detailed, written presentation of the study and the experimentation protocol was sent at their e-mail addresses. The consent form was also sent by mail for information though printed copies were also provided on site, before the end of each session (see APPENDIX VIc).

The decision of contacting University departments, narrowed further down the age of participants from 18-30, to 18-23. However, despite the efforts for including equal male and female representatives from each University Department, the sample consisted of 4 male and 2 female representatives of the School of Fine Arts, and 2 male and 4 female participants from the University Institute of Technology in Social Sciences (IUT), so as to balance the distribution of male and female participants.

5.4.3 WELCOMING THE PARTICIPANTS

Before the beginning of each experimental session, participants were welcomed and introduced to the research team (the author-observer and the second researcher or assistant that dealt with the modalities of recording the full session using a digital video camera and a tripod). After the welcome, some first instructions were given to the candidates regarding the two devices, the UMPC and the ARCHOS multimedia recorder. Then the ARCHOS equipment was adjusted on each participant. A small tutorial, provided by the UMPC, was also proposed to the participants for getting acquainted with the use of the buttons of the device. Finally, before participants started their augmented visit, they were assured that it was the guide and not themselves being put on the benchmark.

5.4.4 DIRECT AND INDIRECT OBSERVATION

The observation of the participants was not only a choice but also a necessity. As mentioned in section 4.2.2, the device used was a generic UMPC. Despite the fact that adhesive black tape was used to indicate which buttons were not to be touched, it happened that an unintentional move perturbed the execution of the application, necessitating a direct intervention by the research team in order to bring the application back to its previous state. But even under ideal circumstances, the battery of the UMPC had to be replaced, approximately after 60 minutes of use. For these reasons, "participatory", direct, observation was considered necessary in addition to indirect observation that would occur later by visioning the video recordings. Another advantage of the direct observation approach was that it encouraged communication and discussion with the candidates. Figure 5.2a and 5.2b shows the positioning of the research team and the participants during the observation.

In addition to this "real-time" observation, the interaction of the participant with the guide, the paintings and the environment -including the observer- was recorded by a digital video camera set on a tripod and manipulated by another member of the research team. The participation of a 2nd person was essential as apart from changing the storage medium of the digital camcorder, frequent moving of all the equipment was also necessary because the commented paintings were dispersed in three different museum galleries.

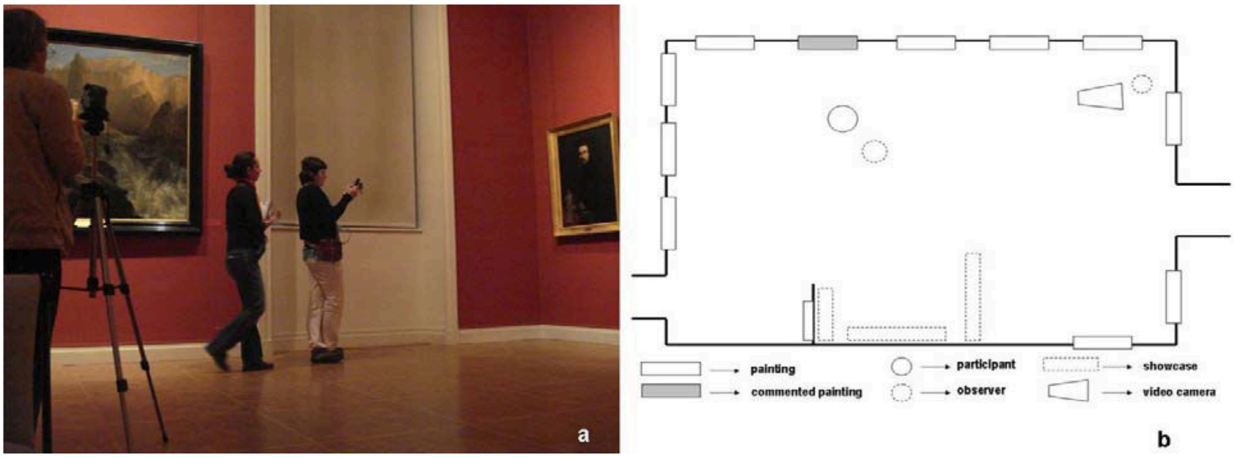


Figure 5.2a-5.2b: A. Positioning of the main actors during the observation, B. Experimental conditions, plan of one of the museum galleries

Finally, as the use of logs was not retained for technical reasons, all details of the interaction of the students with the guide were captured and recorded using an ARCHOS multimedia player, equipped with a head camera worn by the students. The multimedia player itself was placed in a waist-bag, also worn by the students (Figure 5.3a). The observation started directly after the participant had been told to try to locate the commented paintings and then navigate in the application content.

Despite our fears, that shadowing might perturb or intimidate participants, no particular problems were observed and students seemed to feel at ease with the researcher's presence. The double recordings of the interaction of the participant with the device itself as well as with the surrounding environment were daily archived, for further analysis.

5.4.5 SEMI-STRUCTURED INTERVIEWS

In each evaluation session, a minimum of 15 minutes was reserved for conducting a short, post-visit, semi-structured interview. The interview usually took place in the museum amphitheatre and was recorded using the same ARCHOS multimedia recorder that had been used for the recording of the participants' session.

Figure 5.3a-5.3b: A. a student wearing the waist-bag containing the ARCHOS player B. a student wearing the web camera for the recording on the on-screen action

Interviews were essential in order to capture the first impressions from using the guide, while still alive, but were also very helpful in identifying key issues related with the user experience. The warm-up questions were related with personal information regarding the participants as well as relations with museum visiting, while the 2nd part of the interview was mainly focused on impressions from using the guide. Whenever it was possible, some discussion more closely related with the notions of Augmented and Virtual Reality followed, as a preparation for the focus group session that would follow some weeks later. However, as this phase of the experimentation was mainly dedicated to the general look and feel of the application, rare were the times that such occasions aroused.

In practice, however, two interviews had to take place in a more informal environment, especially during the morning sessions, as the slightest delay on the 1st morning session automatically implied that there were chances that the museum closes its doors for midday before the 2nd session reaches its end. The less formal environments that hosted these interviews were not appropriate for obtaining usable audio records for later consultation. Writing down notes in these cases proved essential.

An important remark regarding the interviews taken was that very soon, the diversity of positions and opinions expressed, confirmed the initial hypothesis that despite the small sample used for the experimentations, a survey would be useful both for formalizing the results as well as for preparing the ground for the next evaluation sessions.

5.4.6 THE SURVEY

5.4.6.1 Introduction

Conducting the interviews provided an interesting input as to the topics that should be introduced in the survey as well as for the level of detail of each evaluation key-point examined. The survey therefore, would complement the -exploratory in nature- observations and interviews, allowing as well a formalization of the results as, contrary to the interviews, all participants would have to answer the same set of questions, at the same order.

However, the survey served another very important issue: shedding light -for the first time since the beginning of the experimentations- on the user experience regarding Augmented Reality as a mean for orientation, navigation and interaction with a mobile museum guide. As the selected sample had no prior experience either with mobile museum guides or with the notion of Augmented Reality, special attention had to be given in the formulation of statements regarding the AR aspect of the mobile guide. Because of the highly contextual character of the experimental intervention, the survey included also questions relative with the overall user experience and satisfaction using a mobile multimedia guide in the museum environment, an issue of great importance for the museum stakeholders. As with all other phases of the experimentation, the creation of the survey benefited by the collaborative character of the project, with all involved stakeholders invited to provide input or feedback concerning the survey questions.

5.4.6.2 Content and structure of the survey

The survey was divided in 5 parts and a welcome note or a total of 46 questions (APPENDIX VI) and took in between 7 and 10 minutes to be completed. The 1st section consisted of general questions that helped in formalizing and shaping participants' profiles, especially regarding museum visiting habits and the use of IT.

The 2nd section was entitled "Questions regarding the use of the guide" and included questions related with the usability of the guide, particularly in concern with the use of Augmented Reality for orientation, navigation and interaction in the museum context. The questions were formulated in such a way so that no particular prior knowledge of terminology was necessitated.

The 3rd section was constituted of questions examining the content effectiveness. By "content effectiveness" we mean here both the content in terms of included interpretation material as well as characteristics relative with the effectiveness of the content presentation. This ambiguity was intentional, as we did not want to confuse the participants with questions including terms like "interface".

The 4th section set the goal to explore a sensitive topic, common to the AR-based conception of the guide as well as to the principle of using a mobile multimedia guide in the museum context: the interplays between the visitor, the multimedia guide and the commented painting. The "attentional balance" issue, defined by Woodruff et al. (Woodruff et al., 2002), as the continuous swift of attention of a museum visitor between the environment, the interactive device and other co-visitors had raised the concern of the museum professionals, especially regarding the effects from introducing mobile multimedia guides in the sensitive museum ecology (see also section 2.5).

Finally, the 5th section mainly contained questions regarding the post-visit effect. Though there was no intention of a formalization of the evaluation as to the cognitive impact of the visit, it was judged essential to include a minimum of questions regarding this issue.

Given that the survey had to be as comprehensive as possible, sometimes more than one way was used in formulating "tricky" questions, subsequently placed either under the same section or under another one. The full content of the survey is presented in Appendix VI while the results are presented in detail in the next chapter.

5.4.6.3 "Measuring" the effectiveness of the AR guide

Most of the survey questions were "closed", though open-ended questions, encouraging participants to freely express themselves were also employed in some occasions. On certain occasions, statements seemed more convenient to be employed; participants, in this case, were expected to express their level of agreement.

A Likert-like, 4-point scale was preferred over a 5-point, as the 5-point scale, which includes a neutrality statement, may create confusion between the statements "I am neutral", or "I don't have an opinion" (Albaum, 1997). Therefore, our scale consisted of the "Mostly Agree" statement, followed by the "Somewhat Agree", "Somewhat Disagree" and "Mostly Disagree" statements that during the analysis were attributed a 1 to 4 score. Attention was given in alternating the positively and negatively worded statements, in order to control the "acquiescence" effect, resulting in participants repeatedly giving the same answer (Kuniavsky, 2003, Love, 2005). The 1 to 4 score is reversed in case the preceding statement is negative. An additional advantage of employing a Likert scale is that percentages can be combined with the calculation of usability scores on a 1 to 4 scale, not only for the research questions but also for each participant individually.

5.4.6.4 Survey creation, release and collection.

"Survey Monkey" was used as a tool for the creation and release of the survey as well as for collecting the responses. The basic, free subscription gives a possibility of 100 responses per survey. Participants were invited by mail to fill in the survey that was posted on the web, though a printable version of the questionnaire was also sent by mail. Printed copies of the survey were also available during the focus group sessions.

5.4.6.5 Some post-collection remarks

Despite the fact that all survey questions were scrutinized by all stakeholders, certain misunderstandings proved difficult to be avoided. For example in one of the questions participants were asked if they remembered the name of one or more painters whose work had been included in the guide. The way the phrase was constructed in French could be interpreted both as "Can you recall any of the names of the artists whose work was presented?", as well as "Do you recall one or more names of artists whose work was presented?". As a result, not all students interpreted the question in the same way.

5.4.7 THE FOCUS GROUPS

Finding an appropriate date for conducting the two focus groups, proved to be the more daunting task related with this part of the experimentations. Eventually, it became possible to gather all 12 participants in 2 groups of six persons, approximately six weeks after the beginning of the experimentation process with a difference of 1 day, but in two different environments: The 1st focus group took place in the museum during midday with the presence of our corresponding museum curator, while the 2nd focus group was conducted in Orange Labs, situated near the 2nd University department participating in the study. Both focus group sessions were filmed using two cameras in order to avoid loss of data due to the insufficient capacity of the available video cameras storage medium (Figure 5.4a). In addition, the audio was captured separately using a professional flash audio recorder.

As the available time in each case was limited to a maximum of approximately an hour and a half, the sessions had to be carefully moderated. Five main topics were introduced:

1. Interpretation media in the museum setting and resemblances/differences with the mobile multimedia guide.
2. The interplays between the mobile guide and the object as perceived by the participants
3. Augmented Reality as a mean for orientation, navigation and interaction
4. Other possible applications or scenarios based on Augmented Reality
5. Feedback relevant with the prototype tested

Finally, shortly before the end of each session, "sticky notes" notes were distributed to all participants, who were asked to attribute some "must-have" or "must-have-not" characteristics to the mobile multimedia guide from which a collage was created.

Figure 5.4a-5.4b: Set-up of the settings in which the two focus groups took place

5.5 DISCUSSION

This chapter exposed in detail the numerous factors that affected the creation of the evaluation protocol for the AR enabled mobile guide designed and implemented for the Museum of Fine Arts in Rennes. The first step taken towards this direction was the presentation of current trends and practices in the domain of evaluation of mobile museum guides. The most important remark regarding this issue was that though evaluation initiatives have been accredited sufficient importance, no effort had been made regarding the systematization of relevant evaluation key-points and research questions. In order to fill this gap, a new taxonomy and classification scheme was proposed by the author. Three types of evaluation key points were identified, related with the technological choices, the interactive content as well as with administration issues, while it was argued that all three types can be evaluated with all of the involved stakeholders, namely IT companies, museum professionals, museum visitors and eventually potential sponsors.

However, the particularity of the undertaken evaluation does not just lie in the fact that the type of application examined is still rather innovative; it also inherits particularities because of the featured, still emerging, mobile AR technology. Subsequently, in addition to the state of the art regarding evaluation practices for mobile museum guides, an investigation of evaluation practices for mobile AR applications was also judged essential. The literature review pointed out that AR has not been characterized "technology-centric" without reason, as it does not boast specific design guidelines and has no standardized delivery platforms and interaction components; at the same time it seems that there is a lack of knowledge not only on how to conduct evaluation but also on understanding that evaluation activities are of paramount importance. Within this quite troubling framework, current practices in the domain of AR applications' evaluation were presented as well as some progressively emerging design guidelines, which also helped in highlighting common usability problems susceptible to appear in AR applications.

In order to complete the picture, project-specific methodological considerations, like for example the fact of working with stakeholders and subjects with no prior knowledge regarding mobile AR applications, were also presented. At the same time, the particularities of the environment for which the application was deployed, implied the making-up of an evaluation protocol that had to take under consideration both AR and non-AR related research questions.

Finally, after taking under consideration all of the above mentioned parameters, the mixed-method evaluation protocol, composed by observations, semi-structured interviews, the use of a survey and two focus groups, were presented in detail, together with the experimental set-up. In the next chapter we will take a closer look at the results that the evaluation yielded but also in the ways the gathered data was analyzed.

Table 5.4: Taxonomy of evaluation key points for the assessment of mobile multimedia museum guides

	TECHNOLOGY CHOSEN	INTERACTIVE CONTENT	LOGISTICS/ADMINISTRATION
MUSEUM [M] **VISITORS [V]** **IT STAKEHOLDERS [IT]** **SPONSORS [SP]**	Application implementation (easiness, length, specialised knowledge) Content implementation (who implements and the content and how) Geolocalization/Positioning system Content delivery Content Update Ease of use/accessibility/usability of the modules of the application User interface Linking the pre/during/post visit phase Personalization/Creation of User Groups/profiles Interrelation with other IT infrastructures Ergonomics (weight of the device, holding the device, general use of the device) Robustness of the application System Recovery	**Content quality (text, audio, video, multimedia)** **Content length (text, audio, video, multimedia)** **Relevance with the exhibition/object** **Orientation/Navigation in museum space** **Orientation/Navigation in the application** **Easy switching from the object to the guide/easy retrieval of information** **Learning/Cognitive impact** **Affective Reactions** **Enjoyability** **Ease of use (interface/interactions)** **Transparency/Affordances/Metaphors (clear feedback to the user)** **Distraction/Attentional balance** Social interaction/Isolation **General Visitor satisfaction** **Usefulness** **Usability/Easy or intuitive to use** **User Groups/Profiles/Personalization** **Linking the pre/during/post visit phase** **Robustness of the application**	Business aspects and commercial aspects (eg personalized merchandise) Maintainability/cost of update and maintenance Other necessary infrastructure (network, workstations, content update) Number of devices Cost for devices Training of personnel Number of required personnel Battery Life Registration and distribution process Guarantee Cost of devices Rental price for devices Robustness of devices Interrelation with other IT or museum infrastructures (museum shop, museum café, ticketing system, control of visitors flow) Linking the pre/during/post visit phase

CHAPTER 6

DATA ANALYSIS AND RESULTS

6.1 INTRODUCTION

In the previous chapter we examined the evaluation protocol and its shaping through a thorough literature review regarding both the evaluation of mobile multimedia museum guides and mobile AR applications. In this chapter the methodology for data analysis will be exposed, before delving into the results of each one of the evaluation phases. Regarding the presentation of the results, it is important to notice that apart from the main research questions exposed in section 5.3.5, other issues that had not been foreseen were also detected. For this reason, each evaluation session is presented separately, while the structure of each individual evaluation session is conformant not necessarily with the specific, predefined, research questions but with the classification of the main issues that emerged in practice, through all phases of the experimentations. In the last section, a regrouping of the most important findings of all evaluation sessions is provided.

6.2 SYNCHRONOUS AND ASYNCHRONOUS OBSERVATION

6.2.1 INTRODUCTION

In the time span of approximately two weeks 12 visitors were observed. Despite the fact that all sessions were recorded both by the video camera as well as by the ARCHOS recorder, all participants were also observed throughout the full visit by one of the researchers as explained in section 5.4.4 (Figures 5.2a-5.2b). Extensive notes were taken, while the records of the visit, both from the digital camcorder and the ARCHOS multimedia player were viewed, analyzed and coded after the end of the experimentations. No particular software was used for this video analysis; instead all incidents that occurred were noted, tagged and categorized. Two main categories of findings resulted from this analysis: observations on participants' interaction with the mobile AR guide and the museum environment and incidents with a potential influence on the overall user experience. More in particular, the findings can be distinguished in five different categories:

a) Observations on participants' interaction with the museum environment and the AR guide

b) Incidents related with the experimentation environment

c) Incidents caused by the observer

d) Incidents caused by the hardware

e) Incidents provoked by the interface

6.2.2 OBSERVATIONS ON PARTICIPANTS INTERACTION WITH THE MUSEUM AND THE AR GUIDE

As already exposed in section 3.1, the issue of interaction with the mobile museum AR application is far more complex than the issue of interaction with fixed or mobile interactive multimedia applications. The main reason for that is that the user needs to be primarily considered as a museum visitor whose primary goal is not just to interact with a mobile interactive application but rather with other co-visitors, the museum environment and selected museum objects. This section aims to shed some light on the observed on-site interactions with the mobile AR application, the commented museum objects and the surrounding museum environment. As the visitors' attention switches from the guide, to the environment and vice versa, these actions (interacting with the guide, interacting with the museum environment, interacting with museum objects) have to be correlated and examined the one in conjunction with the other.

After adjusting all the material needed for the experimentations, participants were asked to follow a short tutorial regarding the manipulation of the application and the function of the application controls. Then, the first task visitors were asked to perform was to locate the works for which further resources were available. Once the painting was located, the visitors were asked to freely navigate in the content according to their preferences and preferably exactly as they would do if they were visiting alone. However, in spite of how well the tutorial prepared each participant, the best introduction turned out to be using the guide for real. All participants demonstrated a much better understanding of the application, after having completed the visit of the first painting.

Stressed and less confident participants were more error prone at the beginning of the visit. A common incident was that some users needed time to understand that the entire painting had to be captured in order for the virtual overlays to appear. The audio prompt produced when a painting was detected proved also useful, as it provided direct feedback to the users, whose attention was distributed in between the surrounding museum environment and the AR guide application.

One of the key points of the evaluation was whether the detection of the four commented paintings, using the AR metaphor, was easy to accomplish as a task. Observing the visitors in this case provided considerable input as to the identification of the commented works. Participants in their majority showed ability to identify the paintings in a time span of 1 to 7 seconds. This is quite impressive, as all three museum galleries in which the experimentations took place contained an average of at least 20 paintings. This remark becomes even more determining as it also holds true for the 4th painting, usually lastly visited, the "Bather" of Picasso, despite the fact that the inadequate lightening conditions and the small size of the painting, made it one of the most difficult to be detected by the system. Only two participants met some difficulties in identifying the first paintings, but once the identification mechanism – "scanning" the whole painting- was grasped, they achieved to successfully identify the other three paintings in the same time span as the other 10 participants. Another proof for the easiness of executing this first task is that during the semi-structured interviews it was mainly the author that had to bring up the topic of whether the identification of the paintings was easy or not.

The overall duration of the visits ranged between 25 and 50 minutes according to visitors particular interests. Apart the random and selective activation of each painting's themes, two other schemes of navigation were identified. In the first scheme, visitors followed the proposed order in consulting the content. Other visitors preferred activating the themes in a different but consistent order throughout the full visit (for example, choosing always first the "artist", then the "description", then the "iconography", etc.). Despite the fact that participants were advised to investigate only the themes they were interested in, the majority chose to watch most or all of the available multimedia sequences.

One of the design choices of the application, as described in section 4.8, was the inclusion of a touch-sensitive "Pause" button, displayed on the main window of the application. The "Pause" button provided visitors with the possibility to "freeze" the captured video, so that the virtual overlays stay stable around the commented, video-captured, painting. In English the word to be employed would be "freeze"; in French however, the word "geler" was not found appropriate. This feature provoked several misunderstandings. The 1st one was that as -unlike all other buttons- the freeze button was touch-sensitive, some participants believed, by generalisation, that other virtual overlays were also touch-sensitive. The 2nd one was that many participants tried to use the button for pausing the content of the audio or the multimedia presentations and not for freezing the video, thus revealing a missing functionality of a pause button, also identified during the interviews session. Though the change was relatively easy to implement, it was decided to continue the experimentations maintaining the same configuration for all participants.

Another attitude observed was that the majority of participants that happened to visit first the only painting for which the audio and the text provided was the same, made the reasonable assumption that this holds true whenever an audio is present together with a text. A pleasant surprise was that participants were very careful to what they looked and heard. This became apparent in one of the multimedia sequences for which the audio provided was not completely synchronized with the accompanying image.

Figure 6.1a-6.1d: Visitor attitudes using the mobile guide during the visit.

One of the arguments that have been heard and discussed a lot is that multimedia guides in the museum setting tend to monopolize the attention of the visitors. Therefore, synchronous and asynchronous observation gave interesting feedback related to this matter. Attitudes varied from visitor to visitor, but many participants took pauses in between the multimedia sequences to better contemplate the paintings (Figure 6.1a), did not look the guide when activating an audio commentary, went back and forth, in order to examine the painting closer (Figure 6.1b, 6.1c), while some of them even felt the need to consult the small text etiquettes placed on the wall

(Figure 6.1d), despite the fact that the same information was provided to them by the title bar of each presentation.

Figure 6.2a-6.2d, captures the change of focus and attention, of a female participant, in the time span of 20 seconds. In Figure 6.2a, the participant is reading a text on the UMPC (1:00-1:14"). In Figure 6.2b she is switching from the UMPC to the painting (6.2c) which she fixes for 6 seconds (1:14-1:20"). Finally, in Figure 6.2d (1:21") she comes back to the guide's content.

Figure 6.2a-6.2b: Visitor change of focus of attention, as recorded by the ARCHOS multimedia recorder

A major usability issue was related with the delivery of the audio. As participants were carrying different pieces of equipment, it was decided not to add headphones for the audio delivery but rather use the integrated UMPC speakers. When the museum galleries were calm, no particular problems with the audio were observed. But this was not always the case, as several times, groups -mainly composed of young children- were present in the museum, rendering the listening of the audio comments difficult at times. Some of the students that met this problem tried to compensate it by placing the guide closer to their ears, in order to listen better (Figure 6.3a-6.3b). Since the problem was observed only after the beginning of the experimentations, the decision taken was to continue with the same configuration and not to provide headphones, in order to keep the same experimentation parameters.

Figure 6.3a-6.3b: Visitors trying to compensate the lack of headphones in a noisy environment

6.2.3 INCIDENTS RELATED WITH THE EXPERIMENTATION ENVIRONMENT

As all visits took place in a real world environment, during regular museum opening hours, it was normal that occasionally the museum galleries became noisy and busy, mainly because of school group visits. Whenever there was an accompanying museum educator arrangements were made so as to "share" the museum galleries.

Another significant remark regarding the experimentation environment was the interest that was manifested by other present visitors. This curiosity was especially vivid in case of young visitors and children (Figure 6.4). Other museum staff, for example the museum guards, also manifested a strong interest in the experimentations.

Figure 6.4: Young visitors manifesting their curiosity for the multimedia guide

6.2.4 INCIDENTS CAUSED BY THE OBSERVER

As already noticed, in section 5.4.4, the observation conducted was direct and participative. This way, participants could, if they chose to, communicate with the observer. Help was sometimes demanded at the beginning of some sessions. Other occasions in which the writer-observer had to intervene were provoked by system crashes or in case of a necessitated battery change.

In spite of the tight "shadowing" throughout the full duration of the visits, participants seemed to feel at ease with the observer and the rest of the team, even in cases where other project members were present. As to whether the occasional presence of other museum visitors perturbed the participants, no particular sign of discomfort was demonstrated.

Thought the students had not been explicitly advised to use the "think aloud" protocol, several participants opted for this approach, thus sharing valuable thoughts with the observer during their guided visit.

Finally, intervention was necessary in case participants had to accelerate their visit, particularly if two visits had been scheduled for the morning session. This type of intervention was sometimes accompanied by a certain frustration. For example, one female participant asked whether it could be possible to come back at another time so as to retake the tour.

6.2.5 INCIDENTS CAUSED BY THE DEVICE (HARDWARE)

Another category of incidents observed, was clearly related with the hardware configuration used for the experimentations. Unfortunately the lack of a dedicated platform necessitated the use of commercial, already configured, equipment. In our case, as already detailed in section 4.2.2, we used a Samsung Q1 Origami UMPC together with an ordinary web cam (Chapter 4, Figure 4.1). Out of the four buttons present on the front surface of the device, only two were used as controls of the AR application. However, the two other buttons on the left side of the apparatus were impossible to disable. For this reason, they were covered with black adhesive tape, while participants were told that they should avoid touching them. Despite these precautions, several system crashes were provoked, because the application terminated abruptly by an accidental activation of one of the "camouflaged" buttons.

Because of the decision to record all sessions with the ARCHOS multimedia player using the accompanying head camera, it was absolutely necessary that participants hold the guide at the height of their shoulders (Figure 6.5), so that the interaction with the application can be recorded. Objectively, this was a very tiring position for the participants. Some of them needed to be reminded to hold "correctly" the device so as to obtain effective recordings, while some others were applying on letter the rule and needed to be reminded to take a rest. As a consequence not all ARCHOS recordings were of the same quality. In these cases, the audio recordings of the ARCHOS, made possible by the microphone attached to the head camera, proved to be very useful.

6.2.6 LESSONS LEARNED THROUGH OBSERVATION

The observations provided useful input as to the usability of the AR museum guide prototype but also as to the user experience. Starting from the very specific and then examining the more general or context-related elements of the experimentation, problems related with the interface will be firstly resumed, followed by context specific observations, like the choice of the device used or the experimental conditions.

6.2.6.1 The interface

Consistency proves to be an important element linking most incidents or misunderstandings resulting by the interface design. More in particular, the pattern of identification of the commented works, based on the AR principle, seemed to be understood by all participants quickly, especially after having achieved the detection of the 1st painting.

On the contrary, the lack of consistency provoked several incidents. For example, the fact that one of the paintings revealed the same information in both text and audio, made participants believe that the audio and text content found at the same level, reveal the same information.

The same holds true for the "pause" button. By generalization, some participants believed that the other overlays were also touch-sensitive, despite the fact that they had been instructed which buttons to use for the manipulation of the application. The name chosen for the "pause" button also provoked a misunderstanding but also revealed a missing functionality, the lack of controls for pausing, rewinding and forwarding audio comments and some of the multimedia presentations.

Figure 6.5: Example of the optimal but also uncomfortable position required for the ARCHOS recordings.

Equally related with the presentation of the content of the application, an intentionally included non synchronization of sound and image was observed by most participants, implying that even in terms of multimedia narration, consistency is an important and necessary element.

6.2.6.2 The equipment

The lack of dedicated hardware provoked, as expected, several incidents during the experimentation, as for example system breakdowns because of an unintentional activation of one of the non application-related device buttons or visit disruptions so as to proceed with a battery change. In addition, the recording of all sessions by the ARCHOS multimedia player necessitated that participants hold the device at the height of their shoulders, in a quite uncomfortable position (Figure 6.5). This necessary experimentation equipment, dictated the choice of delivering the audio through the UMPC speakers, a solution that in reality turned out to be problematic especially in cases where large school groups were also present in the same museum gallery.

6.2.6.3 The environment

The unpredictability of other visitors' affluence in the same space during the experimentations was an element that sometimes perturbed the personal choice of the participant as from where to start the guided visit. Another type of incident occurred during the morning experimentations that had to end before midday; so in case two visits were scheduled, a delay during the first visit implied that the second participant might have to be prompted to shorten his visit, so that the interview takes place. In two such cases, the interviews had to be conducted in noisy environments outside the museum, resulting in loss of data.

6.2.6.4 Possible improvements

The importance of this part of the experimentation becomes more apparent when compared with the feedback obtained in other experimentation phases. The most illustrative example concerns the effects of the inclusion of the touch sensitive "pause" button. While other remarks (e.g. the repetition of the same content in a text and audio sequence, the difficulty in hearing the audio when large groups of visitors were present) were reported by the participants in other parts of the evaluation process, the effects provoked by the "pause" button (using the button to pause the multimedia content, or touching other areas of the screen thinking that they are also interactive) were very briefly reported only on one occasion, and by only one participant. As many other participants also faced this problem, it seems that the problem was not reported because it was not perceived as an application error but rather as a "faulty" behaviour from the part of the participants. Apart this remark, it seems obvious from the observations made, that the overall user experience could benefit enormously by an application-specific device, by delivering the audio through headphones and by attempting to record the on-screen action with a more comfortable - regarding participants- device configuration.

6.3 THE SURVEY

6.3.1 PARTICIPANTS' PROFILES

Students of both University departments were aged between 18 and 23 years old with the average age being 20.75. An equal representation of male and female participants was achieved. The participating students own a mobile phone from the age of 15/16, with the exception of two that have been using one from the age of 12 and 14 years old respectively. Regarding the frequency of computer use, 8 students (66.67%) answered that they use one very often (everyday), 3 students (25.00%) regularly (several times per week), and 1 student rarely (several times per month). However, it was noticed that male students use a computer more frequently than female students (Charts' Graph 1).

None of the participants had heard the term Augmented Reality before the beginning of the experimentations. As to the term "Virtual Reality", only 2 students were certain of what it means; 3 were not certain and 7 replied that they do not know. Similarly, none of the participants had used a UMPC or PDA before.

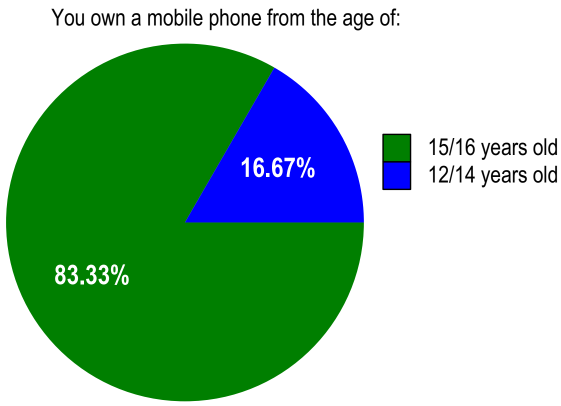
6.3.2 PARTICIPANTS AND MUSEUM VISITING HABITS

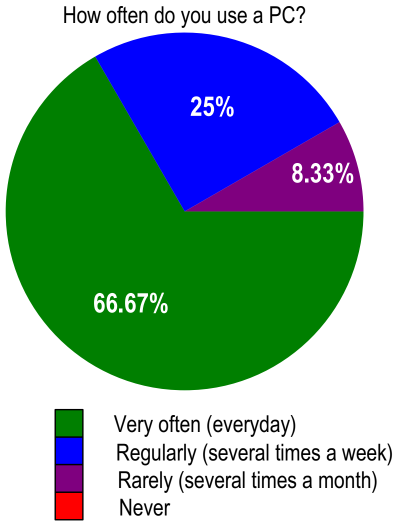
All participants had already visited the Museum of Fine Arts in Rennes prior to the experimentations and had the habit of museum visiting. Regarding the frequency, 7 participants (58.3%) replied visiting museums very often, meaning four times per year or more, 3 (25.00%) regularly, meaning two to three times per year, and 2 participants (16.67%) rarely, meaning 1 time a year or so. It is worth noticing that from the 58.3% representing the frequent museum goers, the 50% corresponds to the totality of the Fine Arts students (Charts' Graph 1).

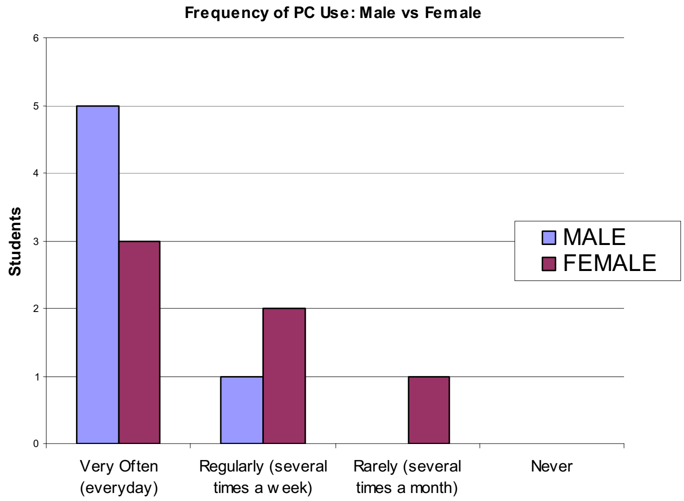
Despite the fact that it is widely accepted that museum visiting is a social activity (Falk and Dierking, 1992), 58.3% of the participants answered that they prefer visiting museums alone. The proportion was larger among the Fine Arts students in comparison with the Social Sciences students. As to whether, once on site, they usually use interpretation material, the answers were equally divided in between "yes" and "no". The proportion was the same between male and female as well as in between the two university departments. As to the nature of the interpretation material used, museum provided printed material comes first on top with (50%), followed by books, web sites and on-site multimedia kiosks (16.7%) and audio guides (8.3%). No participant opted for the "guided visit" option (Charts' Graph 1). Some reasons for that were revealed during the semi-structured interviews (section 6.4)

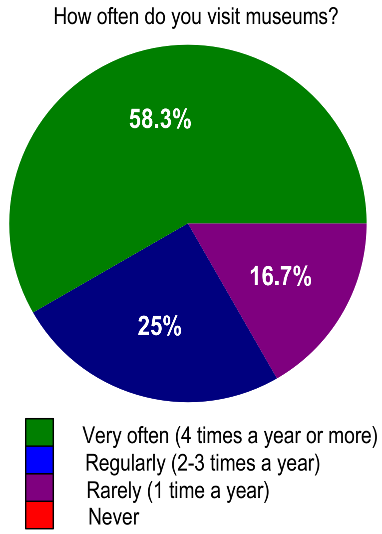
6.3.3 USABILITY OF THE AR GUIDE

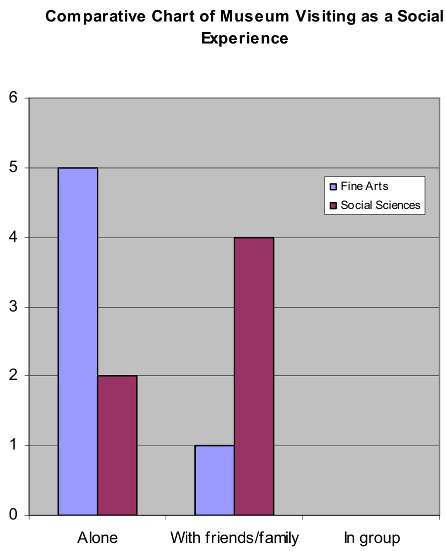
This section, composed of five "closed" and two open-ended questions, was one of the most crucial regarding the main AR aspects of the prototype tested. More particularly, the statements included in this section intended to examine the overall ease of use of the guide, the easiness of identification of the commented works and the easiness of navigation in the guide's content. Finally a statement regarding the help provided by the small tutorial before the beginning of the experimentations was also included.

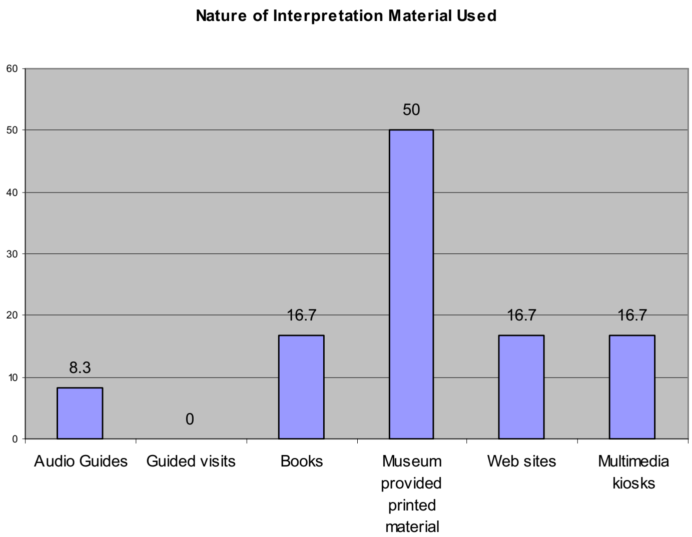




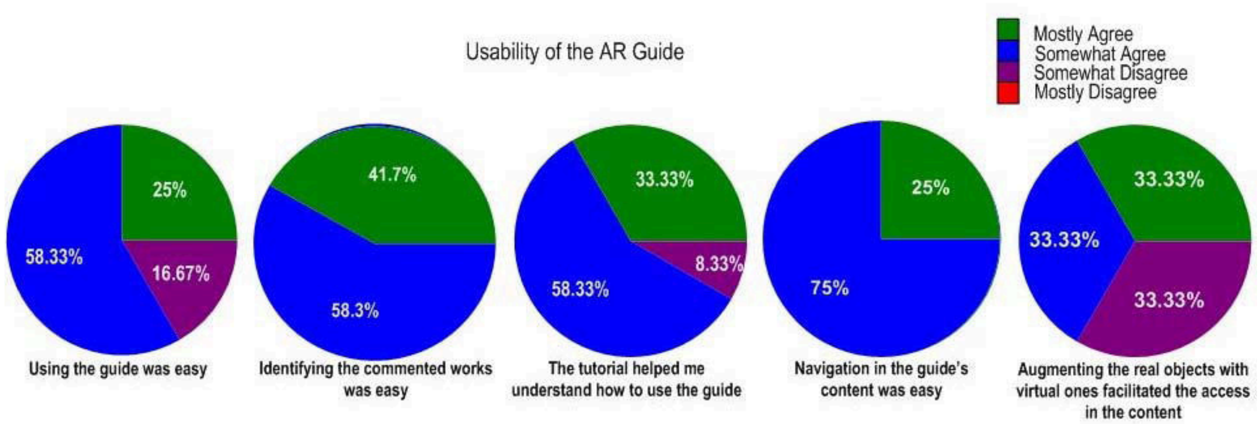








Charts' Graph 1: Visitors' profiles and museum visiting habits



Charts' Graph 2: Usability of the AR guide

The first statement was: "Identifying the commented works was easy" and found 5 out of 12 participants (58.30%) to "Mostly Agree" and 7 (41.70%) to "Somewhat Agree", thus -using the Likert-scale- giving a score of 3.4. The following statement, related with the navigation in the content of the guide was: "Navigating through the content of the guide was easy" and scored 3.25, with 3 participants (25%) answering that they "Mostly Agree", and 9 (75%) that they "Somewhat Agree". The statement "Using the guide was easy" found 3 participants (25%) to "Mostly Agree", 6 participants (58.33%) to "Somewhat Agree" and 2 participants (16.67%) to "Somewhat Disagree" (score= 3.08).

Participants were also asked to position themselves on the statement "The real objects augmented with the virtual ones facilitated the access in the content". The answers given were equally distributed between the "Mostly Agree", "Somewhat Agree" and "Somewhat Disagree" options, achieving a score of 2.25. This is a good example of how the way of formulating phrases can influence the answers obtained during evaluation, given that this statement was included as a complement of the first two, concerning the easiness of navigation and orientation using the guide.

In addition to the above questions, this section also included two, complementary, open-ended questions. 5 out of 12 students (~ 41, 7%) answered the open-ended questions "Is there anything that you would wish the guide do" and "Is there anything that you would wish the guide not to do". The answers are presented in Tables 6.2 and 6.3 and are further discussed at the end of this section.

Finally, the last statement of this section was: "The tutorial at the beginning of the visit helped me understand how to use the guide". 7 students (58.33%) answered that they "Somewhat Agree", 4 students (33.33%) that they "Mostly Agree" while 1 student (8.33%) chose the "Mostly Disagree" option. The scores obtained for the above statements, by using the 1 to 4 Likert scale, are presented in Table 6.1.

Table 6.1: Average scores for the section "Usability of the guide"

Statements regarding the usability of the guide	Average Score (1 to 4 scale)
Identifying the commented works was easy	3.4
Navigation in the content of the guide was easy	3.25
The tutorial at the beginning of the visit helped me understand how to use the guide	3.25
Using the guide was easy	3.08
The real objects augmented with the virtual ones facilitated the access in the content	2.25

Table 6.2: Answers obtained for the open-ended question "Is there anything that you would wish the guide to do?"

Is there anything that you would wish the guide do?	
Participant 1	Having a "return" button.
Participant 2	Be less heavy and provide shorter comments.
Participant 3	That it shows (I don't know what way) directly the details on the painting and that there is interactivity with this one.
Participant 4	Reading was tiring, it could be better only with the audio.
Participant 5	Create a guide that is handy or can be placed somewhere close to us so that the guide is not in between us and the painting.

Table 6.3: Answers obtained for the open-ended question regarding the usability of the guide

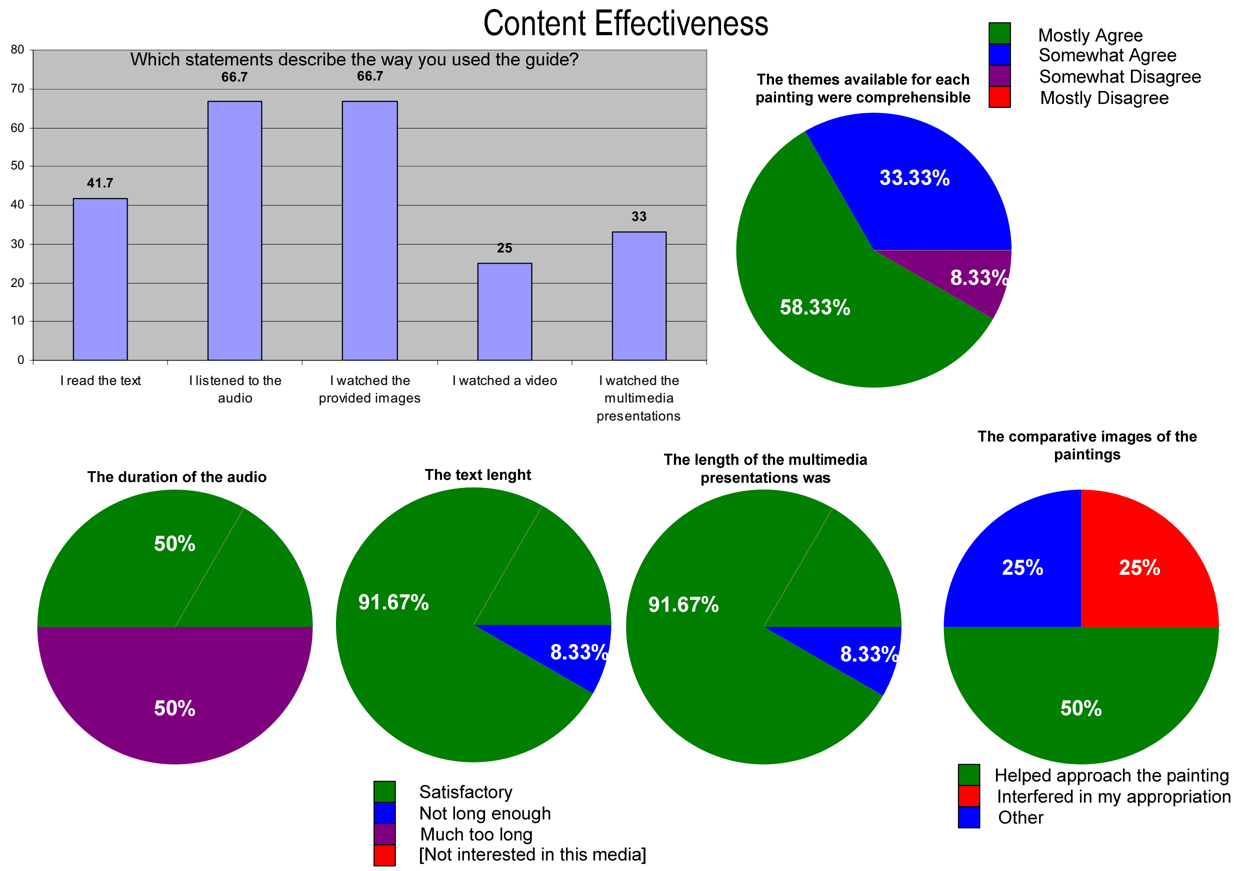
Is there anything that you would wish the guide not to do?	
Participant 1	Indicate immediately after entering the exhibition space the commented work (it should necessitate more move).
Participant 2	Camera…
Participant 3	Distribute it to a very young public (not before 15 years old).
Participant 4	Make as observe only the screen.
Participant 5	(void answer)

6.3.4 MEASURING THE CONTENT EFFECTIVENESS OF THE GUIDE

The third part of the survey was constituted of questions examining the content effectiveness (the notion of "content" was also discussed in section 4.8.1., where the different meanings the word "content" can acquire were highlighted).

The first statement regarded the intuitive comprehension of the available themes, namely the "Context", "Artist", "Description", "Analysis" and "Technique" themes. The score obtained was 3.4, with 7 participants (58.33%) choosing the "Mostly Agree" option, 4 participants (33.33%) the "Somewhat Agree" option and 1 participant (8.33%) the "Somewhat Disagree" option.

One of the most interesting questions included in this section was related to the way participants used the "components" of the multimedia guide. 66.7 % or 8 participants answered that they listened to the audio, 66.7% or 8 participants that they watched the provided images, 41.7 % or 5 participants that they read the included texts, 33.3 % or 4 participants that they watched the multimedia presentations and 25% or 3 participants that they watched a video.



Charts' Graph 3: Content effectiveness

During the multimedia presentations, comparative images were sometimes provided, displayed alongside with the real paintings, so as to create bonds with other, close ichnographically and stylistically paintings. One of the statements of this section tried to investigate whether these images helped the participants better approach the selected paintings or interfered with their appropriation of the selected works. The option "Other" was also proposed as an open-ended option, providing participants with the possibility to express their own feelings if the provided options could not accommodate them. 6 participants (50%) answered that they were helped by the images, 3 (25%) participants that the images rather interfered than helped in the appreciation the paintings, and 3 participants (25%) chose the option "Other", specifying that in some cases they were helped and in some others not.

Four questions of this section were related with the multimedia use in the paintings' presentations. The sentence "The quality of the multimedia presentations was what I would expect from a multimedia guide" found 4 participants (33.33%) to "Mostly Agree", 6 students (50%) to "Somewhat Agree" and 2 students (16.67%) to "Somewhat Disagree". As to the length of the multimedia presentations, participants were provided with the options "Not long enough", "Satisfactory" and "Much Too Long". 11 out of 12 participants (91.67%) found the length to be satisfactory while 1 participant stated that the multimedia presentations were not long enough. Two other sets of questions were related with the quality and the length of the text and the audio provided in the guide. The statement "The quality of the provided text was what I would expect from a multimedia guide" found 11 of the 12 participants (91.7%) to "Somewhat Agree", and 1 participant (8.30%) to "Mostly Agree". On the subject of the length of the text provided, 1 student (8.33%) found that it was "Much too long", while 11 students (91.67%) though that the length was "Satisfactory", meaning neither too long nor too short while none of the participants chose the "Not interested in having text in such a guide" option. As to the audio, the statement "The quality of the audio comments corresponded to what I would expect from a multimedia guide", found 3 students (25%) to "Mostly Agree", 8 (66.7%) to "Somewhat Agree" and 1 (8.33%) to "Somewhat Disagree". "The duration of the audio comments was neither too short nor too long" statement, created a polarity with half of the participants (50%) declaring to "Somewhat Agree", and the other half (50%) to "Somewhat Disagree".

Table 6.4: Average scores obtained for the section of "Content Effectiveness"

Content effectiveness	**Average Score (1 to 4 scale)**
The thematic axes (themes) available for every painting were comprehensible	3.5
The quality of the audio comments corresponds to what I would expect from a multimedia guide	3.16
The quality of the multimedia presentations was satisfactory	3.16
The quality of the available text corresponds to what I would expect from a multimedia guide	3.08

Regarding the scores obtained using the Likert-scale, the best score -3.50- was obtained by the comprehension of the available themes statement, followed by the quality of the audio and multimedia presentations, with 3.16, and the quality of the included text with 3.08.

6.3.5 EXPLORING THE INTERRELATIONS BETWEEN THE CULTURAL OBJECT AND THE GUIDE

This session is one of the most interesting as it demanded from participants to adopt a position as to the impact the use of the guide had on their visit, a topic that has been much discussed and raised concerns from many museum professionals (see also section 5.2.1).

The first statement demanded from participants to take a position regarding the statement "I find that using the guide distracted me from contemplating the real work of art". The answers were scattered among all 4 choices: 4 participants (33.3%) answered that they "Somewhat Agree", 4 participants (33.33%) that they "Somewhat Disagree", 3 participants (25%) that they "Mostly Agree" and 1 participant (8.33%) chose the "Strongly Disagree" option.

The statement: "I find that using the guide helped me better comprehend and appreciate the paintings" found 9 participants (75%) to "Strongly Agree", 2 participants (16.67%) to "Mostly Agree" and 1 participant (8.33%) to "Somewhat Disagree". Participants were also asked to take a position for the statement "I learned more than what I would have learned having not used the guide". 9 participants (75%) expressed themselves positively ("Mostly Agree" or "Somewhat Agree" statements) and 3 participants (25%) negatively (Somewhat or Mostly Disagree). All of the participants expressed a positive attitude regarding the statement "Using the guide was playful" with answers equally divided between "Strongly Agree" and "Mostly Agree" options. The last statement of this section was "The visiting experience was better than the one I'd have having not used the guide". 3 participants (25%) stated that they "Mostly Agree", 5 participants (41.67%) that they "Somewhat Agree" and 4 participants (33.33%) that they "Somewhat Disagree". The scores obtained are shown in Table 6.5.

This section included also two, complementary, open ended questions. The first one was "What did you most appreciate in the guide" and the second one "What did you find most difficult with the guide". 9 out of 12 (75%) participants chose to answer these questions. Tables 6.5 and 6.6 display the obtained answers. Finally, the scores obtained in a 1 to 4 scale are displayed in Table 6.7 and discussed in the conclusions' section.

Table 6.5: The Object-Guide correlation score

Interrelations between the museum objects and the guide	Average Score (1 to 4 scale)
Using the guide was playful	3.50
I learned more that what I would have learned having not used the guide	3.41

Using the guide helped me better comprehend and appreciate the paintings	3.00
The museum experience was better than had I not used the guide	2.91
I find that using the guide distracted me from contemplating the real work of art	2.66

Table 6.6: Appreciated aspects of using the guide

What is the feature you most appreciated in the guide?	
Participant 1	The theme "context"
Participant 2	The power point presentation in the Picasso painting
Participant 3	The unexpectedly highlighted painting details
Participant 4	The playful character of the guide
Participant 5	The playful and at the time informative character
Participant 6	The playful character and the fact that we choose the information to listen
Participant 7	The video
Participant 8	The Picasso painting description, the bathers I think. I liked a lot the power point presentations
Participant 9	The somehow playful use of the guide

Table 6.7: Difficulties encountered while using the guide

What is the thing that you found most difficult?	
Participant 1	The sound, because I could not hear very well
Participant 2	It is a distraction. It takes some time to adapt your self.
Participant 3	The interface
Participant 4	The comparison in between works of art seemed at times not pertinent
Participant 5	The fact that you have to show attention to the explications given
Participant 6	To hear the contents while other people were around
Participant 7	Holding it
Participant 8	I wonder if there is no too much information so suddenly we want to see everything but there is too much and then we hear only a few things...
Participant 9	The guide distracts the attention from the painting itself

6.3.6 QUESTIONS RELATIVE TO THE COGNITIVE IMPACT

Due to the exploratory nature of the study, no formal experimentations were conducted as to the cognitive impact. However it was thought useful to include some questions related with the post-visit effect. The first of the questions asked was whether participants remembered the number of works included in the guide. 10 out of the 12 participants (83.33%) answered correctly more than one month after the visit had taken place. 9 participants (75%) also remembered one of the artists names, while 3 (25%) indicated that they remembered 1 artist but without mentioning a name. Similarly, half of the participants mentioned one or more of the topics represented. Finally, none of the participants answered trying to retrieve relevant documentation after the visit.

6.3.7 QUESTIONS ABOUT AN HYPOTHETICAL, FUTURE USE OF THE GUIDE

Lastly, a set of questions regarding a hypothetical future intention of using such a guide was included in the survey. The first question was "Would you use such a guide, if it was available in the museum?" The students could choose in between "yes", "no" and "maybe". However, the last choice demanded by participants a justification of their answer. 44% answered "Yes" without expressing any prerequisites, while the other 56% said "Probably", under certain conditions. No participant expressed directly that he/she would not use the guide. Table 6.8 resumes these open ended answers.

Table 6.8: Participants expressing prerequisites for a hypothetical future use of the guide

I would probably use the guide	If…
Participant 1	Probably, it depends on the paintings
Participant 2	Probably, according to the exhibition (contemporary/classical)
Participant 3	Probably
Participant 4	For sure, if I was alone
Participant 5	If it was free and less bulky
Participant 6	Yes, If it was free
Participant 7	Yes, out of curiosity in a foreign country

Another subject on whom we wanted to have if not a grip, at least estimation, was the number of paintings the visitors would like to have commented in a guide. 4 participants thought that a total of about 10 paintings would be adequate. 2 others answered that they would like at about 2 paintings for each gallery or each period and style. 1 participant simply answered several, while another 2 would be happy with less than 6. Finally 1 participant said that he would appreciate to have approximately 40% of the totally exposed paintings, while another one asked at about 40. The mean in this case is 10 paintings, a number that might correspond to the number of comments a visitor would be willing to explore. The open ended questions "If you had any expectations prior to your visit, please write them down" and "Is there any comment that you would like to share with the conception and implementation team" did not yield any exploitable answers.

6.3.8 CONCLUSIONS

6.3.8.1 Conclusions regarding the initial hypothesis about the test group profile

The results of the survey confirmed the initial hypothesis regarding the profile of the participants, as occasional IT users, with no previous knowledge regarding Virtual and Augmented Reality applications. The answers were also coherent with the hypothesis of studying a homogenous group in terms of age, but with different museum visiting habits in terms of visiting frequency.

Under different circumstances all participants would have been considered as belonging to frequent museum visitors; after all, they all volunteered to participate in the study and their answers indicate that they visit museums more often in comparison with the average population (Falk and Dierking, 1992). Regarding our study however, it is apparent that the Fine Arts students visit museums far more often in comparison with the Social Sciences students, quite probably because the studying and training curriculum of the first group encourages very frequent (more than four times per year) museum and cultural institutions visiting. For this reason from this point onwards we shall also refer to these two groups as "frequent" and "occasional" museum goers. Museum visiting as a social activity was found to be more coherent with the Social Sciences students, 2/3 of whom answered preferring visiting museums with family or friends. Whether these differentiations in profile can be correlated with the overall acceptance of the guide is an issue that will be further examined in section 6.3.8.4.

6.3.8.2 Use of interpretation material

A strong polarity was observed in the answers given as to whether participants generally use or not interpretation material throughout the visit; only half of the participants answered that they always do so. The answers were equally divided both between the two university groups as well as in between male and female students. Despite the positive or negative answers collected for this question, all participants chose to fill in the question regarding the interpretation material they are more susceptible to use.

As to the nature of the interpretation material used, text provided by the museum comes in 1st place with 60%, followed by on site multimedia kiosks, museum web sites and printed guides of a museum's collection (20%), and finally audio guides (10%). Whether the preference over text is a consequence of the museum reality or an explicit and conscious visitor interpretation choice will be revisited in the interviews (6.4) and focus group (6.5) sections.

6.3.8.3 Ease of use and navigation

Interestingly, the best score obtained in this section of the survey was related with the ease of spatial identification and localization of the commented works of art in the gallery space (mean=3.4), obtained by a 58.3% of the participants that strongly agreed, with the remaining 41.7% mostly agreeing. Good scores were also obtained regarding the easiness of navigation (mean=3.25). These results are particularly important for the overall assessment of the AR character of the mobile application, as in terms of interface, navigation, both in the museum space and in the content of the application, was built upon a consistent use of the AR metaphor.

A somewhat lower score was obtained when participants were asked to judge the overall easiness of use of the guide (mean=3.08); we believe however that the additional equipment used for the study, might have somewhat influenced the obtained score. The lowest score in this section was observed in the statement regarding whether the "augmentation" of the true objects with virtual ones facilitated the access to the content. Despite the fact that this question is strongly linked with the much better performing assertions of the two first questions, the mean obtained was only 2.66, with participants equally divided in between the "Mostly Agree", "Somewhat Agree" and "Somewhat Disagree" statements. This survey question therefore provides a tangible example of the impact the formulation of a questionnaire might have on findings and results in surveys.

6.3.8.4 Attentional balance and user distraction

On of the key topics identified straight after the beginning of the project was related with the introduction of the AR guide in the museum environment, especially in terms of distraction from the real work of art and/or cognitive overload.

According to the results of the survey, it seems that such an issue exists. When participants were asked whether the reference images used for the multimedia presentations in 2D or 3D interfered with their appropriation of the contemplated painting or rather assisted them, the responses were divided; half of the participants claimed that they were helped, with the other half being equally divided between the "interference" choice and the open-ended option. Participants who chose the latter answered that they were sometimes helped and sometimes not. Division was also observed when participants were asked to position themselves on the negatively worded statement of interference of the guide with their contemplation of a work of art (25% "Mostly agree", another 33.3% "Somewhat Agree", 33.3% "Somewhat Disagree" and 8.3% "Mostly Disagree", average score=2.25).

Further analysis and correlation of the answers obtained in this question with participants' profiles indicate that frequent museum goers, felt more distracted (score 3.4) in comparison with participants visiting museum less often, who felt much less distracted by the use of the guide (score 1.8). But this is not the only answer in which results between frequent and occasional museum goers get greatly differentiated.

The mean obtained among the Social Sciences students when asked if the visiting experience was better because of using the guide, was 3.5/4 against 2.33/4 obtained among the Fine Arts Students. The same differentiation was observed in the question asking whether participants felt having learned more as a result of using the guide. In a 1 to 4 scale, the mean obtained by the Social Sciences students was 3.5 as in contrast with 2.33 obtained by the Fine Arts students. Another question, asking participants to position themselves as to whether they better comprehended and appreciated the commented paintings, also revealed differences among the two groups: the mean for the students of Fine Arts was 2.83 and for the Social Sciences students 3.33.

One of the advantages of using the Likert scale is that apart from calculating the mean of the examined group(s), it is also possible to add up all individual scores for each participant separately (Kuniavsky, 2003). This process proved to be quite revealing regarding our two test groups. The mean obtained by adding up the scores of each question for which the Likert scale was applicable gave a mean of 2.96/4 for the Fine Arts students (lowest mean obtained: 2.85/4, highest mean obtained 3.21/4) and 3.3/4 for the Social Sciences students (lowest mean obtained: 3/4, highest mean obtained 3.64/4). Clearly, the overall attitude of the two test groups was not the same. Possible reasons for that will be revealed in section 6.5, where the two Focus Groups sessions are discussed.

It is also interesting to notice that students using a computer very often marked in a more pronounced way their distraction from the real work of art (3.0 versus 2.25 for the rest of the participants) as well as male in comparison with female (2.2 versus 3.3).

6.3.8.5 Edutainment, self assessment of (informal) learning and future use.

The statement asking participants whether they found the use of the guide playful achieved one of the best scores of the survey (3.5), provoking thus less division, with all participants choosing the "Mostly Agree" or "Somewhat Agree" option. This overwhelmingly positive attitude was also reflected on another occasion, and more specifically in an open-ended question asking participants the feature they most appreciated in the guide. 4 out of the 9 participants that responded, replied that the feature the most appreciated was the "playful" character of the guide, while 3 other implied it, as they qualified some of the Picasso content, directly provided by the museum educators, as the most positive element of using the guide.

It is also interesting to check the answers on the statement "Using the guide helped me better approach and appreciate the paintings", where 11 out of 12 participants (91.7%) mostly or somewhat agreed. The same encouraging results were also obtained when participants were asked to evaluate whether they believe having learned more as a consequence of using the guide. We were also interested in including some questions regarding the post-visit effect, like for example the number of works included in the guide. Almost six weeks after the visit, 75% of the participants were able to remember correctly. However even participants who didn't could name one or more of the subjects depicted and/or the associated artists.

Despite the altercation observed in other sections of the survey, all participants answered positively when they were asked whether they would use such a guide in a museum. However one has to notice that 7 out of the 12 participants included their own condition for that; among these answers, two identify as a criterion a topic that was not formally introduced in the study, the additional cost that sometimes is added to the museum ticket for the use of a multimedia guide. Three other participants replied that their decision would depend on the included paintings, another one that he would use it for sure, if travelling in another country, while 1 other that he/she would use it if it was less bulky. Finally 1 participant defined as a criterion conducting a museum not accompanied, but alone.

6.3.8.6 Content Effectiveness

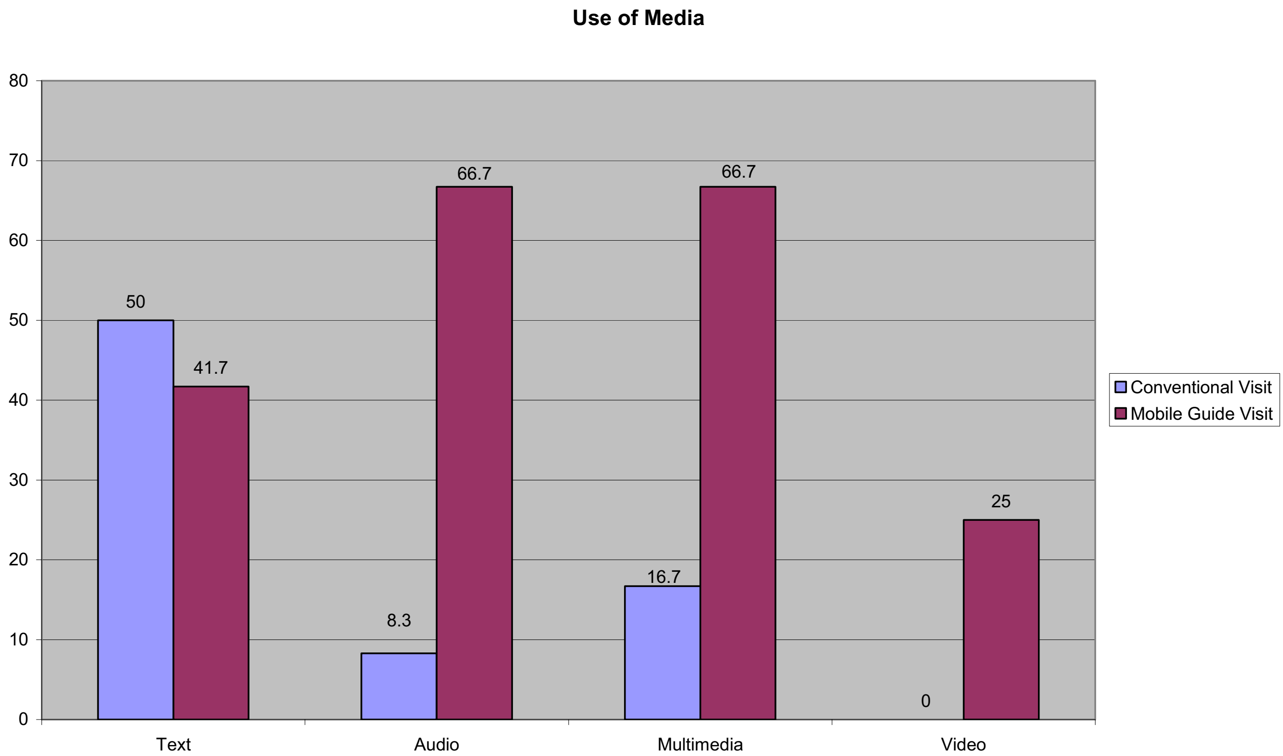
Content effectiveness can apparently closely be related with the above mentioned topic of a hypothetical, future use, intention. The statement regarding the "comprehensibility of the themes" ranked 1st, with a score of 3.5. This was a very interesting result, as during the process of conceptualization of the application, fears had been expressed as to whether the selected title for each theme would be comprehensible. In addition one participant explicitly named one of the themes included as his favorite element of the application, demonstrating consciousness of the distinctive content of each theme.

A polarity was observed in the question regarding the length of the audio comments, which in most cases exceeded the standard 1.30 minute audio guide comment: Half of the participants found the audio recordings to be too long and the other half satisfactory. This result is self speaking as to a certain need for personalization or customization of mobile museum guides so as to fit several different visitors' profiles. Unanimity is observed as to the length of the provided texts and multimedia presentations with 91.7% of the participants judging them satisfactory. This was also interesting as a result for the project stakeholders, as the feeling that the implementation team shared was that the presentations were rather long. Cross-checking this result with the results of the other evaluation methods employed will later highlight once again this issue.

Another interesting question was relevant with the ways participants used the multimedia guide and its content. Despite the fact that all the media provided were eventually used by the students, the audio content as well as the reference 2D and 3D images came on top with 66.7%, followed by the texts (41.7%), the 2D or 3D multimedia presentations (33%) and the video (25%). This finding becomes more interesting when examined together with the results obtained when participants were asked to indicate what kind of interpretation material they usually use while visiting, where the use of text was by far predominant over the use of other interpretation media participants could choose from. Nevertheless, a point demanding attention is that the multimedia character of the guide did not greatly affected the percentages of preference over text; it rather augmented the percentages of preference regarding the audio and the multimedia sequences of the mobile guide.

6.3.8.7 Other issues

Eventually, it is interesting to highlight some other details regarding the obtained answers, in particular the answers obtained in two open-ended questions of the survey. The first one was "Is there anything that you would wish the guide to do?" and the second one "Is there anything that you would wish the guide not to do?". The harvested comments were enlightening. A female participant wrote down that she wishes the guide was handier, or that it could be placed somewhere during the contemplation of the work of art, so that the guide does not *"interfere"* with her contemplation of the painting. In the same direction, another participant answered that he wished the guide was less heavy and provided shorter commentaries while a male student wished the guide was even more interactive *"showing the details directly on the painting"*. Another comment was that the guide should not *"make us observe only the screen"* and that *"it should not be distributed to a very young public, below 15 years old."* An uncommon comment was that the identification of the paintings was much too easy and that the guide should not indicate immediately after entering a gallery, which is the commented work. Finally, a participant gave the single word answer "camera", meaning that he did not approve the "scanning" of the museum galleries with the integrated camera. A last remark is that according to the test group, the number of works to be included in a guide need not be infinite. The most demanding participant requested a 40% of all exposed paintings, while the numbers given by other participants varied in between 6 and 40, with 25% of all participants giving the same "ten paintings" answer.



Charts' Graph 4: Comparative use of interpretation media during a conventional and a mobile guide escorted visit

6.4 SEMI-STRUCTURED INTERVIEWS

6.4.1 ABOUT DATA ANALYSIS AND REPORTING ON THE RESULTS

The interviews conducted with the participants straight after the visit, turned out to give interesting feedback regarding the use of the guide, and one not always foreseen. All records of the interviews were transcribed (Appendix V) and coded using different tags into separate themes. This process can be also visualized in Figure 6.6. The 1st column corresponds to the topics that had been prepared by the researcher, the 2nd column to the list of topics that were eventually brought up, and the 3rd column to the larger issues that were identified after the transcription and coding of the interviews.

As already mentioned in section 5.4.5, the first questions of the interview were personal and used more as a warm-up for the following questions. The "Museum Visiting" part of the interview was then usually introduced. Discussing museum visiting habits allowed a better comprehension of the circumstances under which young people visit museums and other cultural organizations. At the same time participants had the opportunity to express themselves on a subject less peculiar than the use of an AR-enabled mobile museum guide so as to arrive more confident on the questions that would follow, having already established a link with more familiar situations, like, for example, a casual museum visit.

This tactic seemed to work with most participants, giving thus very interesting -1st-person-feedback on some of the issues related with the use of the guide. Excerpts of the interviews are presented below using as a criterion the diversity of the opinions expressed and the originality of the answers given; attention was given to present the answers obtained in a complementary manner for the comprehension of each issue.

Naturally, the issues discussed had some times attributes that could allow the classification under more than one category. However, in order to eliminate repetitions, each identified issue is presented only below one of the four following categories:

a) Findings related with museum visiting habits and strategies of approaching an exhibited object

b) Comments on the overall application content and its structure

c) Positioning of the subjects related to the interface and,

d) The interplay between the painting and the guide

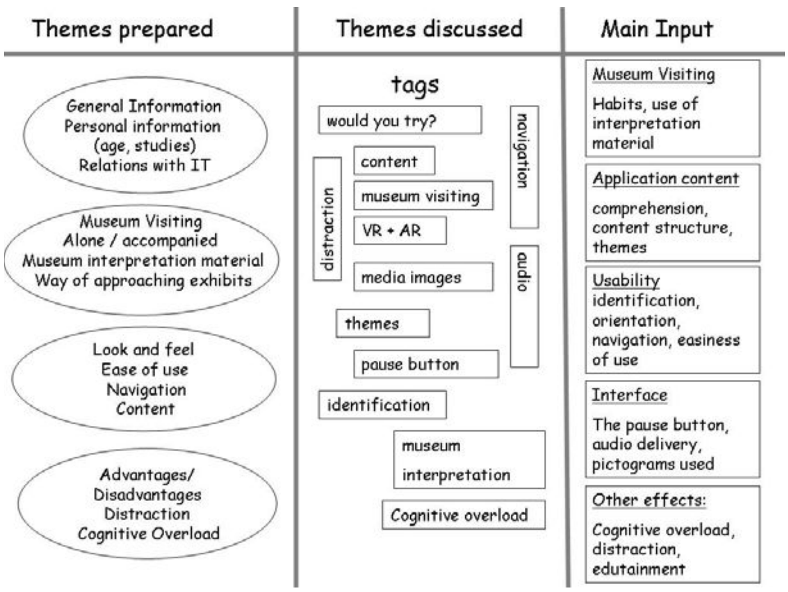


Figure 6.6: Preparation, analysis and reporting of the semi-structured interviews

Regarding feedback related with the AR character of the proposed mobile guide, it is important to notice that though the semi-structured interviews did not provide rich material, they nevertheless served as a way for introducing the term and issue of use of AR technologies that would be later examined through the questionnaires and the two focus group sessions.

6.4.2 PARTICIPANTS ON MUSEUM VISITING

6.4.2.1 Museum visiting as a social activity

Understanding why and how people young people visit museums could certainly encourage a better understanding of the ideal mobile multimedia companion to a museum visit. For example, as it is said that museum visiting is very often a social experience (Falk and Dierking, 1992), several mobile museum guides projects foresee applications for visitors visiting in group (see also section 2.2.5, where mobile museum guide projects are examined in relation with the social context of the museum visit).

In the frame of the Museum of Fine Arts in Rennes experimentations, nevertheless, opinions were divided as to this topic. As it became apparent from the survey results, analyzed in the previous section, the Fine Arts students mentioned more often than the Social Sciences students that they prefer visiting alone; for them, approaching a work of art can be something *"very personal"* (Simon, 20 years old), while in case they share a visit they'd prefer that their co-visitor shares the same background. On the other hand, for the Social Sciences students it seems that *"visiting with others, can be funny, because it allows seeing the impression a painting can make to different people"* (Florence, 19 years old). Nevertheless, even for the students preferring visiting with a companion, the lack of a co-visitor would not prevent them from visiting a museum if they were particularly interested by an exhibition.

6.4.2.2 Approaching the exhibited objects and use of interpretation material

An issue that was extensively discussed with participants was the procedure they follow when conducting a museum visit, in order to approach, contemplate, "read", comprehend, deepen and maintain a souvenir of strong in attractive power exposed objects so as to examine how a mobile guide could better support these tasks.

The first important observation is that visitors identified a need for documentation material in cultural and exhibition spaces. For example, a female students of Fine Arts reported, regarding contemporary art, that *"… what irritates me in contemporary art, is that there is not an enormous offer in terms of interpretation, so I find that annoying"* (Marie-Laure 20 years old). Johan, another 20 year old male student, admits that *"I see a lot (of contemporary art) but I have many difficulties in understanding"* while another participant underlined the fact that even audio guides are far from being the rule in most museums. An alternative and more wide-spread solution consists of museums providing guided tours. For example, in the year 2000, out of the 1108 museums registered in France, 871 proposed at least a guided visit option for museum visitors (ASSEMBLÉE NATIONALE).

Why is it then that none of the participated students opted for the guided visit option of the survey? Some main reasons for that were provided during the interviews session. A female student, answered negatively as to whether she is tempted to follow guided visits: *"I prefer that alternative interpretation material is proposed to me, so that I can choose…I find that a guided visit is often a bit too guided…the personal choice in a museum, passing from one painting to another, is important"*. A male student said that in comparison with a human guide, an audio or a multimedia guide "*gives as the possibility to go around and do what we want"*. The importance of personal choice is also evoked by another student "*I like looking at the paintings and give my own answers, … trying to imagine what it (the painting) represents… when they give me the answer, I do not necessarily agree, I do not always like it, sometimes the explications given just don't appeal to me… This is why I do not like guided visits and I prefer visiting on my own, looking or discussing with the person I am visiting with. This is what I find interesting"*.

This very personal bond of the museum visitor with a selected exhibit was also illustrated in the words of a 20 year old student, from the Social Sciences department, who gave a detailed description of his own way of approaching a painting: *"There are three things in a painting. First of all there is a feeling, what the painting transmits us. For example, the faces, the emotions, or everything else that belongs to this category. Then there is the beauty. Hum…..The beauty both ways. The beauty with its philosophical sense or what is represented. Is it a scene of war or another historic event? And the beauty in terms of aesthetics…Do I like what I see or not? And the third point is the technique."* In the same spirit, a very reactive young man studying Fine Arts, mentioned more than once during his interview that a visitor should *"learn to ask questions that are his own"* and learn to *"see the things for real and live through their reality"* (Florient, 22 years old).

When one comes close enough to contemplate a painting, here is what some of the students said that follows: *"First, I observe a lot the painting with attention, then I read the information next to it, if there is interpretation material it is even better"* (Florence, 18 years old). -*"I stop longer before the paintings I like…"* (Elise, 21 years old). In case text is the only available interpretation material "*…the first thing that I do is to take the museum brochures … I take a look quickly so as to have a personal opinion on what I am watching before I read, but then I take the time to read and I go back to see elements that interest me and that I might have missed…"* (Marie-Laure, 20 years old). Another student replied that *"I might not read the full content…(but)…when there is (interpretation material), I take it…"*.

The virtues of having alongside museum-provided text as interpretation material came on surface on many occasions. A student mentioned *"I prefer guides in form of a book, I like reading (so as) to understand what I am watching"*. The same meaning is conveyed by another participant saying *"I prefer taking my time by myself to read a text, because when we have only the audio, we retain some things but other things are put aside, while with the text, we can take our time"*.

Finally, an unanticipated way of getting more information about selected exhibits was brought up by two male Fine Arts students, who mentioned that they are always equipped with a pen and a notebook. Whenever they spot an interesting work of art, they note the artist and the title in order to search, more information after the visit.

6.4.3 ON THE CONTENT AND THE STRUCTURE OF THE APPLICATION

Another distinct group of questions was clearly related with the content of the mobile museum application, in terms of available themes, content structure and comprehension. The question that was repeatedly asked to participants was whether the structure of the content was clear and comprehensible. The spontaneous answers coming over and over were largely positive; all participants made the connection with the different themes available and expressed personal preferences as to the themes included (description, technique, iconography, artist and context).

Several also remarked that *"we can choose the information we want, and then we choose as well the order"* (Florence, 18 years old). A participant stated that *"If I had retaken the tour alone, I would do the "description", the "analysis" and the "context" but I might have not done the "technique", except maybe the 3rd painting, the one that was very dark (Amaury Duval)"* (Simon, 20 years old), while a girl said that though she found *"very interesting to see how the painting was made",* there were things *"interesting…but maybe not necessary"*. However, relevant with this last point, another participant found that *"It was good to have different thematic axes, because if I need to see only the technique for one painting, I do not have to pass through the full content"*.

The pictograms chosen for each available medium were also judged *"self-explanatory"* with the exception of the pictogram chosen for the slideshow: *"The slideshow was not clear, because the slides were black in color. I understood it after. While the headphones, we understand what it means, and the video the same, we understand what it stands for. The slideshow was the less self-explanatory."*

Another aspect of the content was related with the cognitive overload provoked by the content and the application. The interviews helped a lot in gathering information on this issue, which had not been included in the survey and was by its nature, very difficult to be identified through the observations. The cognitive overload issue appeared progressively, as several students expressed themselves on that point, though they were not explicitly demanded to do so. In most of the occasions, this issue was closely linked with the application content, by many participants. For example, after asking one of the candidates whether the structure of the content and the themes present for each painting were comprehensible, she answered *"Yeah…but there were too many things present at the same time and it is not easy to retain all at once…but otherwise the content was rich, there were many things"*. Another participant, when asked to add any additional commentaries, said *"Well…I liked it a lot, it is nice having all this information, but then of course we can not absorb everything at once"*. Another aspect of the same problem is revealed in the phrase of a male participant who said *"…there were only one or two moments that I was lost, I don't remember when exactly, in the text or in the audio, in the audio…I mean it went too fast, with words that are not employed frequently, so the time to comprehend the words, and try to understand, there was a moment that I was lost…but otherwise it looked clear and simple"*.

6.4.4 ON THE INTERFACE

6.4.4.1 On painting identification

Was it easy to use the guide? That was another question for which we wanted participants to express themselves and one particularly related with the AR metaphor used in the design and implementation of the guide. Some found categorically easy (intuitive) the overall use of the guide and the navigation. Others added that *"We need some time to adapt…"* (Marie-Laure, 20 years old) but *"…once we understand how it works"* (Julien, 22years old) *"it goes fast"*. "*…We go to the left or we go down, and we validate. So for me using it was really easy"* (Johan, 21 years old). Identifying the commented works was also a subject evoked, but none of the participants considered having met a problem with the identification. Moreover, one of the subjects stated that finding the commented works in the museum galleries was much too easy, and advised making the detection more *"difficult"*, maybe *"playful"* (Johan, 21 years old).

Having to "fix" with the web camera the painting so that the virtual overlays appear, was noted by at least two participants. *"Is there really a need to take (capture) a real time video in order to "fix" (make appear) the content of a painting?"* (Simon, 20 years old). *"I would like it more if we didn't have to move"* (Marine, 18 years old). The camera issue was also mentioned in a single word answer also in the survey. This element is important as it reveals that for some of the participants the task to be executed, so that the virtual overlays appear, was understood, but the interaction metaphor was not as well accepted.

6.4.4.2 On interface elements necessitating change or amelioration

Admitting that the identification of the commented works was easy, straightforward or intuitive, which were the characteristics or details that were explicitly mentioned as subject to enhancements and ameliorations, from the point of view of the test group?

The observations regarding the delivery of the audio came first as remark from the test group. A female user, when asked which would be the ameliorations she would advice, said: *"First of all I would put the sound in the ears (I would use headphones) and then I would rather have something handier so that we don't have something that separates us from the painting. And also having the possibility to place the guide somewhere…then we could be confronted with the painting."*

Another comment regarding the audio was related with the absence of a "pause", "rewind" or "forward" control for the audio sequences. The problem was partially identified by a male participant who stated: *"the return button…I found this a little bit strange, I mean…hmm… I know that… I like a lot actually go fast with things, go back, go forward, see another painting and it's true that I missed a little bit the back button."*

The font size adopted for some of the presentations as well as the repetitive character of a text and an audio presentation for one of the paintings (lack of consistency) was marked with a sense of humor by a male participant (21 years old), who described this way his experience: *"The text was very small and I did not have my glasses, I try to read it and then I pass on the audio, and I realize that it is the same thing…".*

Finally, one participant mentioned that he was initially confused by the fact of having to use the touch sensitive "pause button" and the two UMPC buttons. More specifically the participant reported: "*The fact that there is also the touch-sensitive screen, the "pause" button, is a bit distracting…since the guide has to be hold with both hands… touching the guide like that is a bit difficult and we don't know when to use the touch sensitive screen or the button."*

6.4.4.3 On positive interface elements

A distinct group of statements was related with interface and application characteristics that seemed to have a certain appeal to the students.

The presence of alternative media revealing information about the paintings seemed to be appreciated by many participants. *"I don't use audio guides, but at the same time today, the fact of having this, I was happy not to read…because when I found myself in front of Picasso, it looked less intrusive (the guide),* *because there were the images that passed, there were multiple ways to do it…"* (Florence, 18 years old). Another female student (19 years old), expressing herself on the same topic, said: *"Well already, I found very interesting the fact of having the image and the text, and that the text is active, I liked it more than the audio".* The delivery of textual information by means of a computer screen was positively mentioned by the same student, a bit later on. *"You see, recently I was at the exhibition at the … (center of contemporary art, in Rennes) this week, so they gave as a text that was without images, without anything. We are much less attracted to read in comparison with the multimedia guide, so this way it is much easier to read… It was much more interesting than having only text".* Another female participant added that *"I find it very interesting to have other things than only the paintings, and I think this is especially true for people not at ease with paintings and museum visiting…whatever is visual, is very good".* (Charlotte, 22 years old).

Zooming and highlighting some of the paintings' details was also mentioned during several interviews. A female participant (19, years old), said: *"What I liked on the first (painting), was the possibility to zoom in the details…because these are things we usually don't see, and moreover, as they are explained…I mean…we see the painting differently...it becomes not a painting but… a group of smaller images."* Moreover, other participants added that though they enjoyed this characteristic they would prefer that it becomes more present *"I would like the possibility to be able to zoom more in the paintings"* (female participant, 19 years old). *"Otherwise regarding the additional pictures provided, when we are in the description of the painting, I was expecting to see something more interactive, where the image would move, where there would be arrows or indications, a zoom-in or things that will move and change on the image itself…"*(Simon, 20 years old).

6.4.5 ON USER DISTRACTION

A word coming often in visitor's comments was that the guide was *"funny"* and *"playful".* This is normally a positive attribute for an application whose destination is to be used in a multisensory, informal learning and entertainment environment. *"It is true that using the guide was quite playful, this is not bad, and then it allows us having interpretation material on hand"* (Elise, 21 year old). *"It was playful as a thing, and the fact of being able to pass by any information that does not appeal to us is very good".* (Marine, 18 years old).

But when one of the participants was asked whether he would recommend the use of the guide, he said *"Well, one has to develop his critical senses… (so)…it depends on the persons".* Possible reasons for that are provided by the following sayings. According to one participant *"…the fact of having the device on hands makes as watch it. Well then, in the commentaries there are phrases like "look at the painting",* *but maybe finally we watch it less. There is an intermediate, I would say between us and the painting even materially…"* (Marlene, 22 years old).

The interplay between watching the real painting and using the multimedia guide was also mentioned by another participant. *"Well, it's true that we juggle a bit between the two, the painting and the device, but that is what the device proposes…"* (Simon, 20 years old). The attitude one has to show in such a case is to *"…be careful in watching also the painting on its own and take the time to see the things"* (Benjamin, 21 years old). The creation of juxtaposed feelings regarding the multimedia presentations are also illustrated by the statement of another participant *"There was a moment where we had to listen something and at the same time search the different elements on the painting…that was very interesting because at other times it is too much; and we do not look the painting but we are fixed on the device, images pass by and in reality whether we find ourselves in front of a painting or in front of a computer, it would be the same".*(Johan, 21 years old). According to a 3rd participant (Elise, 21 years old), *"Well, I don't know if it should be too playful, because, it is already playful so then it can become too much, because at the beginning there was also the aspect "Oh, it's cool, I am looking for the painting…", then I can click to whatever I want" and then it becomes too playful and we can click wherever without really listening. Because, moreover, at the beginning, as we don't know we click a bit everywhere, on all themes, but not everything interests us, so you see…"*

6.4.5 DISCUSSION

The short semi-structured interviews were of capital importance for the experimentations conducted in the Museum of Fine Arts; first, they turned out as a first barometer regarding the impact and the first impressions from using the application. Secondly, they allowed the author to get to know better the profile of both group of participants so as to better prepare the following evaluation sessions, the survey and the focus group; Thirdly, they allowed the clarification of other issues that arouse in other evaluation sessions. A good example is relevant with the hesitation of the subjects as to their participation in guided tours, while visiting museums. Finally, they gave the possibility to smoothly introduce participants to the notion of mobile AR that would be further discussed and explored during the focus group sessions.

6.5 THE FOCUS GROUPS

6.5.1 INTRODUCTION

The two focus groups were conducted approximately 6 weeks after the visit, and brought together in two sessions the students of each University department that had participated in the study. The recorded videos were analyzed using the free "ELAN" video annotation software and the most representative quotes were translated from French to English (Appendix III). All patterns and themes discussed were identified but attention was also given to silences, tensions, disagreements and humour, often revealing crucial bits of information.

As with previous evaluation sessions, the topics were brought up by the moderator starting from the most general – in our case museum visiting habits and strategies of approaching selected exposed objects- and gradually progressing to the more specific, the use of the mobile AR multimedia guide.

In contrast with the goals of previous conducted experimental evaluation, the Focus Groups had also the intention to bring up the topic of AR, and its possible future uses, especially in the museum setting. The positioning and the feelings of the test group as to the notion of AR broadly speaking were judged equally important. For this reason, a set of three posters (Appendix VI) with other AR applications were presented to both groups as a stimulus to a discussion.

The prepared for the Focus Groups agenda of topics to be discussed was the following:

1) Museum visiting, museum visiting habits and use of interpretation media once engaged in the museum visit

2) Interpretation media available in the museum vs. interpretation media available in the guide

3) The AR character of the application

A short improvisation exercise, consisting of asking participants to spontaneously write down on "sticky notes" notes some "must" and "must have not" features of an ideal mobile guide, was also proposed just before the end of each Focus Group session.

The presentation of the data gathered by both focus groups starts with an introductory note for each group that resumes the timeline of the themes introduced. Some general remarks are briefly presented for each focus group at the end of each relevant section.

6.5.2 THE FINE ARTS STUDENTS (FREQUENT MUSEUM VISITORS)

6.5.2.1 Focus Group Timeline

The session was conducted during midday so the overall duration of the process could not exceed 75 minutes, which is the minimum amount of time normally required for conducting a Focus Group. At the opening of the session, the procedure was once again presented to participants together with an encouragement to be as sincere and spontaneous as possible and the reassurance that nobody will be judged.

As already reported in previous sections, this 1st group of students visits museums very frequently. Therefore the first issue introduced, was the kind of interpretation media participants use when engaged in a museum visit and their way of approaching a selected work of art. However, unlike the answers provided by the same group of participants in the survey, the majority of the students claimed not to use interpretation material in the museum. The question therefore was rephrased as: "If you had to give your professional opinion as to interpretation media to be used for a less experienced public, what would you advise?".

A bit later the discussion focused on the media participants met in the multimedia guide, as well as positive and negative characteristics. This question also had to be rephrased as "what would you change if you made part of the conceptualization and implementation team?". Last but not least the posters were presented to the participants who were encouraged to share feelings, opinions and ideas regarding AR and its potential applications. The main themes and patterns that emerged during the discussion of these issues are presented below.

6.5.2.2 Use of interpretation media and strategies of approaching a work of art

Participants of the 1st group self-referred to themselves as initiated museum visitors on several occasions. For example, while talking about interface aspects, one participant said that regarding the initiated in history of art group he is representing, accessing quickly a maximum of information in a minimum of time is crucial. Another participant said *"Maybe we are more at ease (with works of art) or we have more sensitivity…I think it is also our curiosity that makes as have this perception of things"*. In several other occasions participants differentiated themselves from the average or less experienced museum visitor profile.

The discourse held over the 1st topic introduced in this session, the use of interpretation media in the museum and the ways of approaching a work of art, was long and passionate to a degree that sometimes necessitated the intervention of the moderator.

Two were the most important themes that emerged from this section. The 1st one is the variations observed regarding visiting habits and preference over different interpretation media. The 2nd one was that several candidates questioned the "raison d'être" and the actual use of these media in the museum. The following excerpts are illustrative.

The first student to talk was Florien, a 22 years old male student. Florien visits museums very often as most of the students of this group. He usually looks for exhibit related information after the visit and for him all media, books, Internet, video, are good for that. He does not need to take notes because if he likes something *"it stays engraved"* in his memory. For him, *"Everything happens in front of the object"*.

The convictions of Florien did seem to influence a female student of this group that used the same exact words, *"it all happens in front of the painting",* adding however that, as opposed to Florien, she usually takes notes and if there is available text she might consult it. The need to take notes was also evoked by a 3rd, male, participant. A somewhat different approach is revealed by the position of Marie-Laure, a female, 20 years old student. *"I always start by reading texts before I go to an exhibition. Personally I prefer taking the information before and watch the work after and then discuss about it."*

Her saying provoked an immediate reaction from the part of two of her colleagues. The first one said: *"Yes but in this case you are more than oriented when you enter in an exhibition."* A 2nd one added: *"if you go and start to bother for what this or the other person or art historian said, your approach is not personal, you will eventually have the a priori of these persons. Somehow it will alter your subjectivity and your perception"*.

The female student whose sayings provoked these reactions provided an interesting counter argument: *"Yes, but at the same time sometimes, like for example, in the exhibition [name of the exhibition] that I saw the previous weekend, it was the opposite. There was no explication at all, there were only words on each stand, so visitors kept asking themselves what the objects were doing there and what was the relation between the one and the other. It is important to have some information so as to be able to "read" the work of art. … it is important to appreciate something while looking at it…"*

But what about other media, like interactive multimedia kiosks, audio guides or guided visits? According to Benjamin (male student, 21 years old) *"whenever there is a multimedia kiosk I start taking a distance".* As to audio guides, one of the participants clearly mentioned that she never uses it: "*I would not like to have audio. I am more attracted by text. The audio, I never use it, it gives me a headache after 5 minutes, and then, why bother with the description of a work if you have it in front of you? I 'd rather have information on the artist or on what he made".* The way audio is sometimes used by the large public, was vividly described and mimicked by Florient (Figure 6.7). *"For me, the audio perturbs. I was in an exhibition the other day in Paris. People take a device, they pass before the works, they watch and when they see a little number, they go straight for that and they are literally scotched in front of it, and when the comment finishes, hop, they go…I can ask from these people what it is that they remember from the exhibition….they haven't seen anything."*

6.5.2.3 On the content and the structure of mobile museum guide applications

Despite the turbulence provoked by the discussion of the advantages and disadvantages of using a mobile guide in the museum setting, a theme that imbued the whole session, even the more reserved students articulated their feelings and ideas about the ways of providing and presenting exhibit related information. While discussing about museum interpretation media and strategies of approaching works of art, Julien, a male student, said that there are things on which he would like to have information, for example a description, but that regarding feelings or senses that an object evokes, he would rather trust his senses. The topic was further analyzed by another participant:

Figure 6.7: A Fine Arts student mimicking the way audio guides are sometimes used in museums ("They are almost scotched in front of it")

"I would advise the use of the guide in case it sets the good questions. We talked about this during the interview, if you remember… I said that the museum educator who was present in the museum the other day with a group of children, asked: "What do you feel?" For me this is very important, because when we go to a museum the important thing is to live through objects and things and cultivate our sensitivity…People that are amateurs and do not have solid knowledge, will not know how to set these questions on their own. There is obviously a reason, if we like or don't like something." A bit later, he also added: *"It is this kind of questions that should appear in the guide, the ones that encourage visitors to ask themselves questions about what they feel, the ones that cultivate their sensitivity not just "I go to a multimedia kiosk and I learn what the artist has to say", not that. Because the artist sets the things but also wants to provoke feelings and senses."*

Here is what another participant said on the same subject: *"I agree on that. It is necessary to ask the right questions, not just say: "this is the reason for which the painting was made"…not to reveal everything at once…make people feel the need to look for information on their own."* Four other participants agreed; only one student noted that not everybody entering a museum will have the will or the time afterwards to try to search relative information.

6.5.2.4 On the content of the mobile museum guide application

As to the way this principle was employed in the tested prototype here is what another participant said:

"Me, what I felt is that everything was given, we were not concentrated on the object, on what happened in front of our eyes…OK with the multimedia kiosks, but personally I am not fond of guides…but if this is the case maybe after the exhibition…"

As a solution to that, one of the opinions expressed was that *"giving information either at the beginning or the end would make visitors set the right questions…as the principle of a museum is to show things but also help people develop their own feelings regarding the objects exposed"*.

Regarding the content of the guide, interestingly, one of the issues that were introduced by participants themselves was related with the matter of personalization or customization. For one of the female participants, providing the content in several languages is a very important issue as well as targeting one or several groups, for example children. The example of children as a target group for the specific application was also brought up by another participant *"Addressing it (the guide) to a specific visitor profile is important, for example, children might need to focus more on colors, or sketch something so as to represent a detail…in this case the guide would need to be playful. And there are also other categories of people that might need a guide like this"*. Later on, the same participant provided another idea, to be able to *"transform the painting on the screen, like changing the colors and see how we can transform the painting and then be able to print that and take it home to have a small souvenir of what we did"*.

However, the idea of a virtual visitor intervention on a work of art did not provoke unanimity among the other students. One of them said *"Maybe I am a bit old fashioned, but I think that a work of art should not be touched because there would be a risk to overdo it. I 'd rather have a practical guide rather than funny"*.

This preposition found another supporter who said that: *"…playfulness is already part of the perception of a work of art. We play even if we don't interact directly with the work of art. There is a playful part in the perception of things, and this way of playing is personal. There are fantastic works of art that invite people to interact with them."* Additionally the participant expressed his fears as to young children using the application in a clear and concise way: *"…well I think that kids could be manipulated, it would be only game… If we impose to kids to understand and perceive the world of art like that…well they could as well stay home to visit virtual museums…This is what I want to say."*

6.5.2.5 On positive and negative application elements

As the dialogue regarding the use of interpretation material did not cease, after all participants had expressed their feelings, a re-orientation of the discussion towards the actual application tested, was judged essential. Participants were asked what would be their personal touch regarding the application if they made part of the implementation team.

The first problem to be evoked was once again related with the audio delivery. A participant said *"the audio, include headphones or something like that, in any case, for me it was the audio that did not function well"*. He then added *"I did not quite understand this system of "we take a video of something"*, *but anyway as the painting is in front of us we do not need to look the work on the screen. To have to fix (with the camera) the work so as to see it after on the screen, I found this a bit annoying."* For another student the application makes the visitor *"fix the display"*. This last participant, however, managed to turn his critique into an idea of how he would like the guide to be modified. *"Maybe what should be done would be to fix the painting but then (after the detection) make it disappear from the screen so that we can choose the themes. Like that we would be obliged to look at the real painting."*

At this point, the previously speaking participant intervened once again, pointing out the "pause" button problem: *"navigation is very important and as there was not always a back button we could not always go back at any moment"*.

Another question introduced in the Focus group, was whether during the use of the guide, participants experienced any kind of emotion. The first response was related with the content and the presentations provided by the museum educators for the Picasso painting or -in participants' words- *"the child approach in the work of Picasso, to see the power point with the content elements that appear progressively makes the reading of the painting more interesting"*.

Regarding the length of the presentations and as opposed to the overall good results obtained by the survey, one male participant said: *"Maybe some passages need to be shorter, as sometimes they were quite long…as we already knew some things on the paintings, not everything interests us, so we will not look at everything…the best thing would be to be concise and give the maximum of information quite quickly, because (while on the visit) we did two themes and then we felt like going to another painting as we had already stayed a long time before on one painting"*. The level of detail of some of the presentations was also mentioned by another participant. *"It is good to have interpretation material…but maybe not this abundance of information, at the same time that we watch the painting, but leave a mystery side, for example, receiving information without knowing which work it accompanies and try to guess"*.

Another compelling idea that arouse during this part of the process was linked with extending the visit beyond the museum physical space as one participant propose to *"keep in memory the information and then provide it (to the visitor) at the end of the visit, in a digital storage media or something like that"*.

6.5.2.6 Reaction towards AR and its use in the museum setting.

The last part of the Focus Group was dedicated to a discussion around AR as an emerging technology. Participants of both groups were shown a set of images illustrating other AR applications (Appendix 6). The reactions from the 1st Focus Group were very vivid (Figure 6.8), while viewing the photos provoked laugh from the part of some participants. The sayings of the following two participants are indicative as to the very reserved if not negative reaction that was provoked. Benjamin, for example, said: *"I find interesting watching all that, however if I go to a museum it is not so as to see something through glasses. I am OK with the principle of receiving information, but for the senses (the feelings) if we all put glasses…It is not possible, we will have a view where everything would be integrated, a vision already constructed"*. For a 2nd participant *"The people that will start using these things, will not be able to do without them, they will not have the mood to go and search for things themselves."* Finally a 3rd participant made a comparison with the extent to which mobile phones have become an indispensable accessory of our everyday life. *"I think that there is a need for a medium that will help people develop this curiosity, because if we invite people at this comfort, go to a museum, put on glasses, and a pair of headphones, the day they will not have that they will be lost…like it now happens with our mobile phones, when we don't have them"*.

6.5.2.7 General remarks and conclusions resulting from the 1st Focus Group

There are several remarks that have to be made regarding the frequent museum goers Focus Group. The first one is the influence of one of the male participants over the other present students. Either the way the participant expressed himself was very successful as to what other participants felt, or the conviction by which he expressed himself had an impact on other participants. An argument towards the second hypothesis is provided by the fact that the survey results found half of the focus group participants to admit that they usually use interpretation material once engaged in a museum visit. However, during the Focus Group, only one of these three participants explicitly explained why and how she does use textual information.

Figure 6.8: Reactions provoked by the AR posters presented

As already pointed out by the survey results, the Fine Arts students were quite critical as to the possible side effects the use of a mobile multimedia guide could provoke. However, the critique expressed for other interpretation media, such as audio guides or museum provided texts, provides a more general framework under which the hesitations regarding the possible use of a multimedia guide should be examined.

A second important remark has to do with the way of ending the session. The issue of AR, lastly introduced provoked a strong emotional reaction from the part of the candidates. Once the first three expressed their reservation, the remaining students did not judge essential to position themselves. Finally, it should be noted that the presence of our corresponding museum curator might also have a slight effect on the way participants expressed themselves as to their relation with museum visiting.

6.5.3 THE SOCIAL SCIENCES STUDENTS (OCCASSIONAL MUSEUM VISITORS)

6.5.3.1 Focus Group Timeline

The timeline followed resembled the timeline followed for the 1st Focus Group with one single exception: Because of the reaction provoked by the AR posters shown shortly before the end of the 1st Focus Group, the 2nd FG session started with an introduction on AR for which the same series of posters were demonstrated, then put aside in order to proceed with the proposed agenda. Another important difference as to the timeline, is that the available time for conducting the 2nd Focus Group was extended, by approximately 15 to 20 minutes.

6.5.3.2 Museum Visiting and the Issue of Museum Interpretation

The 1st warm up question directly addressed to the participants was about the reasons for which they might visit or not museums often. Several reasons were identified: among them, the price of the entrance ticket, the lack of time, as according to several participants one has to take time to visit. A female participant argued that museum visiting necessitates an initiation and it is not always a *"spontaneous initiative…It is like going to the theater, if you do not take the habit while you are young you will not go when you grow up"*. As to museum visiting as a social activity, some participants responded that they enjoy sharing their visit in order to exchange opinions and ideas, while others said that they prefer visiting alone.

Very quickly, the issue of interpretation also arouse. Put by one of the participants *"we often hesitate to go because we are not adequately informed and once in front of a work we feel a bit limited"*. Another participant defined the missing kind of information as the one that make someone better *"see the work and appreciate it"* or as a 3rd participant said information to *"understand the works, because even if you are initiated that does not necessarily mean that you understand all kind of works of art"*. When participants were further encouraged to talk on how they feel faced at a situation like this, one of them answered that *"we do not feel at the right place"*.

Not all participants agreed on that matter. A male participant differentiated his attitude and said that *"personally I am not bothered, even if I don't understand, for the pleasure of my eyes; I am not blocked to go to a museum and see things without explanation. Then I can create my own story and I am happy"* (Johan, 21 years old). As a response, one of the female participants that had previously also identified this issue repositioned herself, saying that *"having an explanation, sometimes guides our vision of a work of art"*.

6.5.3.3 Interpretation material used and strategies of approaching a work of art

The next issue introduced was relative with the media that are usually available in the museum and the media that were present in the multimedia guide. All media, namely text, audio, video projections, paper guides, human guides, the World Wide Web and multimedia kiosks were identified by the participants.

The following topic introduced aimed to identify how this 2nd group of students usually proceeds if attracted by a particular work of art. Taking photos as a souvenir, or retain the name of the artist and look for related information after the visit were some of the first answers obtained. As the museum of Fine Arts in Rennes also provides two multimedia kiosks, the students were asked whether they had already used them. With the exception of one participant who said being aware of their existence but not particularly attracted by them, none of the students had given a try to the multimedia kiosks though they had already visited more than once the Museum of Fine Arts in Rennes.

6.5.3.4 On positive and negative application elements

The next question aimed at encouraging participants in identifying characteristics and elements that they liked or did not like in the tested application. Regarding the content, a female participant (Elise, 21 years old) said that she found very funny and interesting the fact that infrared and ultraviolet photos of a painting were included allowing to locate later modifications and that she enjoyed the details that jumped out of the painting. As opposed to the augmented details, no other participant shared the same enthusiasm for the infrared and ultraviolet pictures.

The issue of audio delivery was also brought up very quickly by one female participant (Marine, 18 years old) and made also other participants agree that it could be better if the audio was delivered by a headset. At least two participants mentioned, while spontaneously mimicking their moves during the visit, that as they had to approach the device closer to their head so as to better hear, they could not see the images that passed by, during some of the multimedia applications (Figure 6.8c-6.8d).

A related issue discussed was whether they would prefer a single or double audio headset. Most participants said they would prefer a double headset *"because the quality of the sound would be better",* but one participant clearly explained that she would appreciate a single headset as she does not like being isolated from the environment: *"With a double headset you hear nothing else at all…and personally I am stressed not to hear what is going on around me".*

Diverse opinions were observed even on the subject of whether holding the guide was tiring or not (Figure 6.8a-6.8b). However the most interesting result of this remark is that some participants demonstrated a clear understanding of the role of the "pause" button as a mean of freezing the video and the virtual overlays that appeared around the painting on the screen. This was demonstrated by the fact that they asked other participants who said that holding the guide was tiring, whether they used the "pause" button, for taking a rest.

Regarding the presence and the use of the different media in the guide a female participant indicated, with a negative connotation, that she was not expecting to find text, given that alternative media -such as audio, video, slideshows or augmented views of the painting- were included in the guide. Exactly as observed in Focus Group 1, not all participants agreed on the importance of each medium employed. For example regarding text, one female participant stated: *"Personally, I prefer the text, because I can concentrate more easily, and I could not hear very well the audio contents, while with texts, if there was something I could not understand, I could reread it; it is much simpler like that"* .

Another issue that emerged was the interplay between the real work and the guide. Johan, a 20 year old male student, mentioned that at times *"we were with our eyes fixed on the screen and not on the painting, so I told myself that if I was home in front of my computer visiting virtually the museum, it would be the same. At times I was forgetting the painting that was in front of me".* Another participant said that *"having the computer between us and the work, made that sometimes we were not watching the painting…I'd like to be able to place the guide somewhere and just watch the painting".*

Figure 6.9: Participants imitating uncomfortable positions while using the guide

As in contrast with the discussion held during the 1st Focus Group regarding this issue, two participants of the 2nd Focus Group expressed their disagreement with this view. One of them said *"I did not have this impression, … especially with the description we could hear the commentary and then see the work for real with all its details".* The other disagreeing participant said that *"I was not blocked on the screen, because I was switching from the screen to the painting and vice versa".* A possible solution to this problem, heard also during the 1st Focus Group, was to make the painting disappear from the display after the detection and leave on screen only the themes.

The issue of distraction arouse once again further on during the Focus Group shortly after the brainstorming regarding other possible applications or functions that could be embedded in the guide.

Participant 1: *Well I think that (if the guide is too playful), it biases the visit, because from the moment we start playing we forget the things we saw.*

Participant 6: *Yes...*

Participant 1: *Today I have few souvenirs of what I learned the day of the visit though I remember there were many things I liked, so by focusing too much on the playful side, we loose the actual information.*

Participant 5: *It depends because there are things that can develop other things...the comments can help you develop your critical spirit, do we agree or not, we automatically set the question to ourselves, so as to form our own opinion.*

When, a bit later on, participants were asked what their general impression from their experience was and whether they believe that the museum should invest in a guide like that, they said:

Participant 2: *Well then we have to see whether we have to pay for it or not, because if it costs 10 euros… Then, I would not put this kind of thing in between children's hands…There were special guides for that in the museum that manage to create a dialogue with the children…I would not want to imagine all these children with their little headset and their little device…they should be at least 15 years old… for children, it is better to encourage guided visits…*

Participant 2: *It is true it demands concentration and maybe not all kind of persons could stay at the guide (the content) all the time.*

As to the easiness of painting identification, one of the participants shared with the other members of the group a problem he had also mentioned during the interview.

Participant 3: *The disadvantage that I found is that we did not really look around us, and the reason for which I was deceived was that right after we entered the gallery, the device immediately detected the painting. It was too easy. I would like that the guide detects the work once we are closer, let's say from a distance of 1 meter from the painting, then we show him the work and it says "This is the painting... " . Like that we would have the time to also see the other (non commented) paintings...a kind of "walk around" mode…I was deceived not to have to look for the painting!*

Participant 6: *I don't agree with you. For me the identification was not that easy…*

Participant 5: *Yes, but isn't it a bit the context of the particular visit? It is a prototype we were testing. In case we were in a real museum visit, I would be looking with more time other paintings and I would chose the ones that interest me. It is true we were focused on the guide but it as greatly the (experimentation) context that made that.*

Finally, another disadvantage discussed by the participants was that of the selective inclusion and therefore also exclusion of works of art available for consultation on the guide.

Participant 4: *I think we were more attracted by the commented works, so maybe unconsciously you pay less attention on other works*

Participant 4: *While if all the paintings were inside, it would be ourselves choosing what we want, so this way we would look only what would be of more interesting to us.*

Participant 3: *It is true, that if all paintings were included this problem would stop being a problem.*

6.5.3.5 Reaction towards AR and its use in the museum setting.

At least two times during the discussion, participants expressed the opinion that they were expecting something even more interactive. This was a good starting point for reintroducing AR and its potential as a mean of orientation, navigation and interaction. More specifically participants were asked to try to make an abstraction and imagine that their display is not a computer screen but a pair of AR see-through goggles. The first reaction came from a male student that spontaneously completed one of the sentences used by the moderator.

Participant 3: *Do you mean that everything would happen on the painting? I think that with a pair of glasses we would have more the impression of watching the painting as well as the information that comes to be added on it. But then again we'd have to try.*

His saying provoked a reaction from a female student who said:

Participant 1: *I think I would not like that at all, because I would have the impression of having something introduced between me and the painting, it would not be my eyes that would watch, and they would be filtered by something. I would feel trapped even if I could deactivate the added information.*

Participant 2: *Yes but the glasses could be removed…*

Participant 3: *I think that we would have to try whether it is the painting you see or whether you have the impression of being in front of a PC.*

Participant 1: *Yes, but knowing that there are things that will pass in front of your eyes, even if it is (the glasses) transparent, there would be something in front of your eyes. This something would be imposed to you and you would have to look at it.*

Participant 3: *It is what is happening with the GPS actually, there are some devices that can project the information right in front of you while you are driving, I think it is something like that.*

Participant 1: *Yes but I want to see my own reality, if they talk to me about Augmented Reality I just don't want it to be augmented.*

Participant 4: *Or at least be able to choose*

Participant 1: *Yes, exactly.*

The silence was then followed by a set of ideas regarding alternative ways of using AR in the museum.

Participant 1: *Eventually maybe we could project something…with a video projector that would display the information and a mirror that would send back the image to us reversed, with all the information. But in that case we would have to wait for the ones that interest us to pass by.*

Participant 4: *Of course not! All information would be projected and you could choose.*

The issue evoked then was how the think they could interact with the AR system.

Participant 3: *With a remote control!*

Moderator: And what would there be on this remote control?

Participant 3: *Arrows*

Participant 2: *If not we could do like that* (moving hands up and down, see Figure 6.10)

Moderator: You mean something like a movement detector?

Participant 2: *Yes, exactly*

Participant 1: *It could be nice being able to use your body*

Participant 4: *Or maybe there could be something on the floor indicating where you have to move your body to go (navigate) to on or the other place.*

Figure 6.10: Participant demonstrating a possible way of gesture interaction with a mobile AR museum application

Talking about ways of interacting with the AR application, the issue of commanding the application by voice was also introduced. Participants agreed that they would not really like that, especially in the museum, and that that they already have enough of the automated voice menu they use, sometimes without success, when using their mobile phones. Some of their words was that *"This is not evident"*, or even *"It is ridiculous"*.

The next question introduced was what the participants would change if they made part of the conceptualisation team. The dialogue that followed was very interesting:

Participant 2: *Its playful side ! Personally I would place a mouth on the painting and it would be the painting that would talk to me*

Participant 3: *It is the persons on the painting that would talk*

Participant 2: *And we see a mouth appearing on the paintings*

Participant 5: *Yes but with the persons of the painting*

Participant 6: *(laughing)*

Participant 4: *If not include games based on the paintings before or after but focused on the depicted subject*

Participant 2: *And a "paint" application so that we can virtually draw on the painting*

Participant 4: *(laughing)*

Moderator: Would you be interested in a function that would allow making notes?

Participant 2: *Yes*

Participant 4: *How de we call this thing in the museum where anybody can write before walking away?*

Moderator: You mean the visitors' book where you could leave your comment… Would you be interested in watching other peoples' comments?

Participant 4: *Yes!*

Participant 3: *Something resembling the blogs principle, you see a picture that you like and you can make comments or consult others' comments if you want*

Moderator: And what about taking pictures?

Participant 4: *It could be a nice souvenir of you with the painting!*

The abundance of ideas regarding possible interactive characteristics of an AR guide, made a participant question herself and the group whether the guide becoming too playful might be related with issues, presented in section 5.2.1.

6.5.3.6 Remarks and conclusions resulting from the 2nd t Focus Group

Comparing with the 1st Focus Group, the discussions held among the 2nd Focus Group were more balanced with the sense that no participant dominated the discussion. As this group of students belongs to occasional museum visitors, it was also possible to discuss reasons for which people might visit or not museums frequently. What was equally interesting, especially in conjunction with the fears that have been expressed by the 1st Focus Group, regarding the fact that museum interpretation material might guide more than necessary a visitor's vision on a cultural heritage object, was that for students of the 2nd group, interpretation material seems to be important for their appreciation and understanding of a work of art. However, even among the 2nd group at least two participants explicitly mentioned that interpretation material can indeed influence the way a museum object might be perceived, while the notion of "discrimination" of commented objects against not commented ones was also introduced.

Participants of the 2nd Focus Group were also more receptive regarding the use of the guide, without this meaning that they were not critical as to issues such as the audio delivery, the attentional balance, the media used etc. It is nevertheless significant to notice that even for issues such as whether holding and using the mobile guide was tiring or not, opinions were also juxtaposed.

Naturally, controversies were also observed when the discussion started turning around the AR character of the guide. Again, despite the diversity of the opinions expressed the 2nd Focus Group seemed to be more open than the 1st one. This might be also partly due to the fact that not only there was more time available for the discussion, but also because the posters presenting other AR applications were presented at the beginning and not at the end of the session. As a consequence, during the 2nd Focus Group, various interaction ideas not only regarding the tested prototype but also a future one were heard and discussed.

6.5.4 AN ADDITIONAL FOCUS GROUP EXERCISE

Shortly before the end of each session, a small "exercise" was proposed to students of both Focus Groups. "Post-It" notes and pens were distributed and participants were invited to attribute must and must-have-not characteristics of an ideal guide. This exercise built on the principle that sometimes it is a common tendency for people to think of inanimate objects as having human-like characteristics (Wasinger and Wahlster, 2006).

Some of the human-like characteristics attributed by the participants to an ideal guide were *"sensitive", "original", "curious", "relaxed"* and *"subjective"*. Other adjectives employed by the participants were: *"motivating", "complementary"* and *"optional", "educational", "playful, "amusing"* and *"surprising", "different", "interactive", "discrete"* and *"practical",* but also *"source of reflection",* to be addressed to *"as many people as possible"*. At the same time the ideal guide should not be *"obligatory", "selective", "heavy in content"* or *"boring"*.

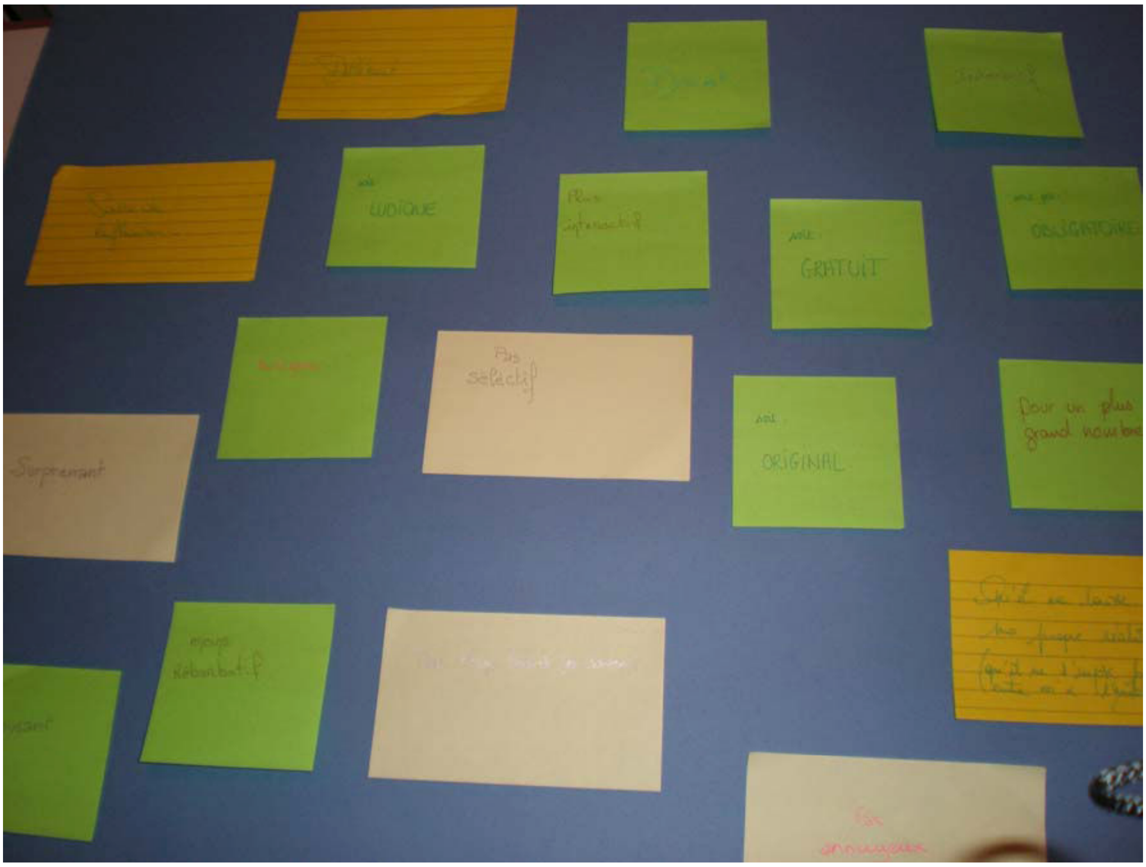


Figure 6.11: The poster of "must-have" and "must-have-not characteristics" as created by the participants

6.6 SYNTHESIS OF THE MAIN FINDINGS AND RESULTS

6.6.1 INTRODUCTION

This chapter presented the results yielded in all evaluation phases, regrouping them whenever that was possible in distinct thematic units. In this last section an overall regrouping of the most important detected issues is attempted, in order to provide an even more intelligible apprehension of the evaluation outcomes.

6.6.2 USING AR FOR GEOLOCALIZATION AND NAVIGATION

Before presenting our findings as to the main research hypothesis related with the use of AR as a mean for geolocalization and navigation in an interactive mobile museum guide, it would be useful to resume the main ways the AR metaphor was employed in the design and implementation of the proposed prototype.

A) Geolocalization and Painting Identification: The visitor, holding the guide, “scans” the surrounding environment, so as to discover the commented paintings. When a painting has been detected, a visual alert, in the form of a question mark, informs that a commented painting has been found.

B) Navigation in Subthemes: When the visitor approaches the commented painting and views it through the screen of the UMPC, oval virtual overlays, each representing a specific subtheme, appear arranged around the painting.

C) Selecting among different types of available media: Each time one of the five subthemes is activated, new virtual overlays each representing a different type of medium (text, audio, movie, 2D or 3D slideshow), plus a return button, appear arranged around the screen (Chapter 4, Figure 4.15).

D) Navigation and manipulation of the multimedia presentations: According to the type of the activated medium, the content might either cover the totality of the display or complement - registered in 3D- the examined painting. For example, a depicted person or a detail might “jump out” of the painting. When a multimedia sequence is launched, the visitor can navigate forwards and backwards using the joystick of the UMPC (Chapter 4, Figure 4.15).

E) In addition, a “freeze” touch sensitive button was provided. This was proposed so that the visitors navigate in the content without having to continuously film with the attached webcam the commented paintings.

In order to accomplish the above tasks and proceed with the guided tour, the participants had to:

A) Understand the “scanning” metaphor and, additionally, realize through practice, that the paintings had to be “scanned” not partially but in their totality so as to be recognized by the system.

B) Understand the proposed navigation scheme and, using the joystick, move and/or activate one subtheme after the other.

C) Understand that each of the selected pictograms appearing under each subtheme represents a different medium.

D) Understand that when sequenced 2D or 3D multimedia material was activated, the UMPC joystick could be used to go forward or backwards.

E) Understand the role and function of the "freeze" button.

With the exception of the fourth step, the first three steps consistently built on the AR metaphor both for navigation in the museum space (identification of the commented paintings, scattered among a majority of non-commented paintings) and for navigation in the multimedia interpretation material of the interactive application. Having decorticated the AR inspired metaphors used for the interaction with the proposed prototype, we can now proceed in examining more carefully each of them.

A) Observation demonstrated that the "scanning" of the paintings in order to discover the commented ones was an easy and intuitive task for the majority of the participants (section 6.2.2). Only in a few cases the subjects faced difficulties, but eventually all 12 participants understood the metaphor. Stressed and less confident visitors were more error prone regarding this issue. The results of the survey are conformant with the issues detected during the observations; the statement "Identifying the commented works was easy" achieved one of the best scores (3.4/4) with all students choosing either the "mostly agree" or "somewhat agree" option. The relevant data provided by the semi-structured interviews and the Focus Groups is also coherent with this picture. In addition, the fact that the identification issue did not arise as a main discussion topic neither during the interviews nor during the Focus Group session also provides a proof that this task was comprehensible by most participants.

B) The quantitative and qualitative results also demonstrate that the navigation using the proposed subthemes was equally well understood. During the observations three schemes of navigation were detected: i) random navigation from one theme to the other, ii) consistent use of the proposed order for navigation in a linear way and iii) consistent but not linear activation of the proposed subthemes. The findings from the semi-structured interviews in which the issue was brought up were also consistent with the observations, as well as the survey results; all students either strongly or somewhat agreed with the "easiness of navigation" statement that achieved a score of 3.25/4. A supplementary element as to whether the navigation scheme proposed was intuitive or not, is that during the Focus Group sessions that were conducted approximately six weeks after the visit, many participants were able to describe in detail the way the navigated in the application proving retention of the navigation scheme over time.

C) The same holds true for the association of each pictogram with a particular medium. The only relevant comment as to this point was that some pictograms –for example the pictogram selected for the slideshows- were less self-explanatory than some others (audio, video, text). The Students of Fine Arts also commented that the graphic design, in particular the 3D ovals and the selected pictograms, could have been less basic and more “artistic” (Semi-structured interviews and Focus Group 1).

D) A problem appeared with the forward/backward navigation in some of the multimedia sequences, manipulated using the UMPC joystick, because no visual cue was given. Nevertheless the majority of the participants intuitively used the joystick without being instructed to (observations). Finally, regarding the available controls, many participants pointed out that in addition to the “return” (escape) button, they would like to have a pause, back and forward button for the audio.

E) Another graphical user interface related problem was the touch sensitive “freeze” button that, as mentioned in section 6.2.2 provoked two types of incidents. The first was that some participants thought, by generalization, principally at the beginning of the tour, that other virtual overlays (e.g. the subthemes), are also touch-sensitive. The second was that the role of the button was misunderstood by some participants who tried several times to use it not as a “pause” but as a “freeze” button.

From the above, we can induce that the proposed navigation scheme was quite well accepted. In this sense, we can consider that the performance of the AR based navigation and interaction scheme was successful. But, as we will see further on, that does not necessarily come with a hypothetical wide acceptance of AR technologies in the museum environment.

6.6.3 AFFECTIVE REACTIONS REGARDING AR

In section 6.3 the results of the survey were presented in detail. The “usability” part of the survey was of special interest regarding the AR character of the mobile museum guide application. As we saw above, the results concerning the identification of the commented works in the museum galleries and the navigation in the guide’s content were quite encouraging. However, when a bit later on, participants were asked whether “The real objects augmented with the virtual ones facilitated the access in the content" opinions were considerably scattered. The answers were equally divided between the "Mostly Agree", "Somewhat Agree" and "Somewhat Disagree" options.

This can be considered as a paradox, especially if this evidence is compared with the results obtained for the statements "Identifying the commented works was easy" (score 3.4) and "Navigation in the content of the guide was easy" (score 3.25), because both identification and navigation were based on the use of virtual overlays augmenting the viewed, real, scene. Besides the fact that this issue provides a good example of the importance in the formulation of the research questions, how could this inconsistency be explained?

Focus Groups provided interesting insights as to this matter. During both Focus Groups comparable reactions were noted when the issue of AR technologies and applications emerged. The posters prepared for the Focus Group sessions (Appendix 7) provoked vivid reactions from participants of both groups, but not less than the term "Augmented Reality" itself. For example a female student (2nd Focus Group) admitted that she wants to see her own reality, and does not want it to be augmented (section 6.5.3.5). The same attitude was conveyed by the sayings of a male student (1st Focus Group) who said that his vision would be *"already constructed"* and that if he goes to a museum it is not to "*see something through glasses"*. A 3rd participant also reacted (1st Focus Group) by saying that *"The people who will start using these things, will not be able to do without them, they will not have the mood to go and search for things themselves."* Finally, a male participant compared a hypothetical intrusion of AR displays with the intrusion of cell phones in our everyday lives, precising that if visitors get used to this comfort *"the day they will not have that they will be lost…"*.

6.6.4 SUGGESTED POSSIBLE AR INTERACTION IDEAS

Despite these reactions provoked to both Focus Groups, it seems that for the 2nd Focus Group (occasional museum visitors) it was easier to turn the initial discomfort and disagreements regarding AR technologies into feedback as to possible ways AR could be used in the examined content. According to a male participant it would be interesting to try in order to see *"if everything happens on the painting"* or if we have the "*impression of being in front of a computer screen*".

As to the ways interaction could be achieved with a fixed or mobile AR display, participants of the 2nd Focus Group discussed several possibilities such as voice, gesture or movement command of the application. An interesting AR scenario was also exposed, consisting of animating the personalities depicted on paintings, thus "allowing" them to narrate their story in the 1st person.

6.6.5 AR APPLICATION DEVICE AND DELIVERY

The creation and evaluation of the prototype tested was marked by several constraints. For the users of the AR application, the most important was the lack of an appropriate terminal in terms of size, weight and adapted application controls. Additionally, the participants had to carry on them the ARCHOS multimedia player for the recording of their sessions, wear a small head camera attached to a strap around the head and cope not only with the observer and the other members of the research team, but also with other museum visitors that happened to be present during the experimentation sessions.

Therefore, it comes as no surprise that some of the usability issues identified by the participants themselves are related with the above mentioned experimental conditions. Several participants mentioned the weight of the prototype and the fact that it was not "handy" enough; a student wished that there was at least a "place to put the guide", while one participant noted that he had difficulties activating with his fingertip the touch sensitive "pause" button, as the guide had to be hold by both hands.

Another issue, detected multiple times during the observations, the semi-structured interviews, the survey and the Focus Groups was the delivery of the audio. The UMPC speakers performed well when the environment was quiet, but in cases of strong visitor affluence, participants faced difficulties in hearing the commentaries.

Observation revealed that the role of the "freeze" button was not clear enough. Some users tried to use it unsuccessfully in order to "freeze" the audio and some of the multimedia presentations while others, by generalization, were brought to believe that other graphic elements on the screen, like the pictograms used to represent the available media, were also touch-sensitive.

In contrast with the above problems that were detected principally by means of observation and were not commented by the participants themselves, the need for a "pause", "rewind" or "forward" button in the audio sequences and in certain multimedia presentations was clearly and explicitly mentioned by many participants, in more than one of the evaluation phases.

6.6.6 SUBJECTIVE VISITOR SATISFACTION

Despite the circumscription of the equipment configuration, the large majority of the participants decided to go through the full content of the application, though the instructions they had been given encouraged them to consult only the content that most appeals to them. Moreover, some of the visitors, when prompted to accelerate the visit, demonstrated signs of a certain frustration.

The identification of the commented paintings in the museum galleries was an easy task for all participants, especially after the detection of the 1st painting while navigation in the content of the application by manipulation of the virtual overlays representing the themes, proved to be straightforward and intuitive. Testimonials are given not only by the quantitative analysis (survey) but also from the qualitative, as participants referred often to their favorite or less favorite themes, even during the Focus Groups, approximately six weeks after their visit.

Browsing the content of the application was not performed mechanically. A single non synchronization of image and sound was perceived and commented by most participants while a single case where the content of a text and an audio commentary was the same was mentioned more than once during the interviews. Generally speaking, the large majority of participants seemed to be rather invested in the AR visit.

The results of the survey answers that demanded from participants to self-assess their visiting experience are also informative. All participants, with the exception of one, had a strong or moderately positive attitude as to whether the guide helped them to better approach the paintings. Good results were also obtained when they were asked whether they think they learned more in comparison with a conventional museum visit, as a consequence of using the guide (3.08).

However, it is important to notice at this point the correlation among some of the results obtained in the survey with the two different visitors' profiles that participated in the study. The score obtained by occasional museum visitors regarding whether the visiting experience was better as a consequence of using the guide was much higher (3.5/4) compared with the score obtained by the frequent museum visitors (2.33/4). The same scores were also obtained by the question asking participants to self-assess whether they think having learned more because of using the guide. Also, the question regarding the comprehension and appreciation of the commented works of art achieved a 3.33/4 score among the occasional museum goers, against a 2.83/4 score among the frequent museum goers group. When all scores from all questions were added up to find the mean for each participant separately and then for each group, the same tendency was observed. Among the occasional museum goers, the lowest score observed was 3 and the highest 3.64 (mean 3.3) while among the frequent museum goers the lowest score was 2.85/4 and the highest 3.28/4 (mean 2.96).

A very high score (3.5/4) was obtained regarding the playfulness of the tested guide as all participants chose the "Mostly Agree" or "Somewhat Agree" statement. The mean was the same for both groups that participated in the study. In addition, the word "playful" appeared as an answer in open-ended questions of the survey no less than 6 times. The topic was also evoked during both Focus Group sessions. However, a particular point demands further attention. The word was not used in a positive way at all times. That does not mean that the participants considered that the word has a negative connotation. A closer look at the discussions held during the Focus Group, shows that in the experimentations conducted in the museum of Fine Arts in Rennes, participants seemed to worry regarding the degree to which this "ingredient" could be present in a mobile museum guide application. This remark brings us to the "attentional balance" issue, which is further examined in the next session.

6.6.7 ATTENTIONAL BALANCE, USER DISTRACTION AND COGNITIVE OVERLOAD

In which way the admittedly playful character of the guide could be related with the issue of attentional balance (else the division and constant switch of focus, concentration and attention from the actual painting to the mobile museum guide and vice versa)? The participants' comments and the feedback of the participants were very enlightening as to this issue.

Using a student's words, "*It is true, (the guide) demands concentration and maybe not all kind of public could stay at the guide (the content) all the time*". Another participant said that this happens because, especially at the beginning of the tour, "*we don't know, we click a bit everywhere, on all themes, but not everything interests us*". *"We juggle a bit between the two (the painting and the application)",* another participant said, *"but then again that is what the application proposes"* while sometimes *"… (the fact of) having the device on hands makes as watch it"*. *"The guide distracts from the painting itself"*, and this is probably one of the reasons for which one of the answers given in the must-have-not characteristics of the guide, was that *"it should not make us observe only the screen"*.

A special concern was exhibited concerning a possible use of the guide by children in three of the four evaluation phases (interviews, survey, focus groups). The participants who made this remark suggested that children might have the tendency to get absorbed by the guide and use it as a game with a repercussion on their discovery of the real exhibition space. As suggested two times, one in each focus group session, if it is to watch the paintings on the screen we could as well stay home *"visiting virtually the museum"*. It is maybe for these reasons that a female participant suggested answering in one of the survey questions, that the guide should not be used by children who are less than 15 years old ("… *I would not put this kind of thing in between children's hands…There were special guides for that in the museum who manage to create a dialogue with the children…I would not want to imagine all these children with their little headset and their little device…"* (P6)). A participant of the 1st FG reported on the same issue that he believes that *"kids could be manipulated,…If we impose to kids to understand and perceive the world of art like that…" (P1).* Though it is not completely rational to make guesses as to the effect a mobile multimedia AR guide could have on children, it is true that often enough children of young age that happened to be present during the experimentations manifested a vivid interest for the experimentations and especially for the guide.

The attentional balance issue is also linked with a possible cognitive overload provoked by the amount of information available in the guide. In a survey comment, a student wrote *"I wonder if there is no too much information so suddenly we want to see everything but there is too much and then we hear only a few things..."*). Somebody else talked about an "*abundance of information, at the same time that we watch the painting."*

Taking under consideration these comments it becomes maybe more unambiguous, why despite the fact that 11 out of the 12 participants expressed themselves positively as to whether using the guide was helpful towards approaching the paintings and 9 out of 12 believe they learned more, only 4 stated when asked that they did not feel distracted by the guide. It is however important to notice that the mean obtained among the occasional museum goers regarding the negatively expressed statement "I find that using the guide distracted me from the real work of art" was considerable lower in comparison with the frequent museum goers (2 against 3.5/4).

6.6.8 PERSONALIZATION/CUSTOMIZATION

Customization and personalisation of services and devices is an important issue related with human computer interaction with a (presumable) decisive effect in the overall user experience. As already demonstrated in section 2.2.4, this issue has already drawn the attention of the scientific community of Cultural Heritage Informatics. An additional reason for that is that museums are by definition open to the society and deliver messages to diverse publics in terms of age, interests, and needs. Therefore it comes as no surprise that many aspects concerning the personalization and adaptation of museum related information technologies have been treated on several occasions, including the mobile multimedia museum guides' context of use. For these reasons, the experimentations in the museum of Fine Arts in Rennes did not intend to examine thoroughly the interrelations between visitor profiles and acceptance of the AR enabled mobile guide. However, in the course of the evaluation process rich and informative evidence appeared that sheds light on the ways different museum visitor- profiles, interests, preferences, wishes and needs could influence and inform the conceptualisation and design of a mobile multimedia museum guide.

Should mobile museum guides cater for the needs of visitors visiting with family or friends? Should a multimedia guide provide also textual information? What about audio comments and which should be their duration? Would visitors rather prefer a single audio headset to a normal one? And what about linking the museum visiting phase with the post-visit experience? Several of the issues that came to light during the evaluation phase had not always been foreseen.

According to the answers of the participants museum visiting might not always occur as a social activity. While some of the participants enjoy visiting museum with companions, discussing and exchanging ideas with them, some students clearly expressed that they either prefer visiting museums alone or accompanied by a companion who shares the same background.

Interpretation is not consistently used. Apart the (not so) obvious regretted absence of interpretation material, especially regarding contemporary art (as cited by participants themselves), other reasons that were identified were:

a. the fear that interpretation material might be selective, including some works and excluding others,

b. the fear that the provided interpretation material might impose the a-priori of other persons

c. the fear that a suggested tour might be "too guided"

d. the fear that the interpretation material might reveal information that will dissolve the very personal feeling an exposed object might provoke to a visitor

However, even the more reactive against the use of whatsoever interpretation material students, admitted that for a public not possessing specialized knowledge on history of art, a kind of aid might be indeed needed. The need but also the wish of a non-specialised museum visitor to better approach and comprehend a tacit work of art became more than apparent during the 2nd Focus Group. Statements like *"We often hesitate to go (to a museum) because we are not adequately informed and once in front of a work we feel a bit limited"* or even *"we do not feel at our place"* express the frustration a visitor might experience in the effort to "read" and then "interpret" a museum object.

Another interesting conclusion is that not all interpretation media have the same effect on visitors. The students of both groups held long arguments as to the pros and the cons of text, audio, guided visits or multimedia kiosks. While a student of the 2nd group negatively commented that she did not expect to find text in a multimedia guide, another student said that comparing with paper-printed text, she enjoyed reading using the guide. The same participant admitted that she never uses audio guides and that for this reason she was not interested by the audio sequences of the multimedia guide. However, a bit later, one of her colleagues mentioned that though she usually reads texts and does not use audio, she found very interesting and useful the inclusion of different media in the guide and enjoyed for a first time hearing an audio comment while watching a painting.

The use of text in the mobile guide deserves a specific mention. The results of the survey show that text comes on top as to the frequency of use in comparison with other media during a "conventional" museum visit. However, comparing with the answers as to the use of the available in the multimedia guide media, the text retains more or less the same percentage, despite the fact that the use of the audio and the multimedia climbs from 8.3% and 16.7% to 66.7% respectively. Some good reasons for that were provided during the Focus Groups. Comparing the audio with the text, one participant said that she feels it is easier to concentrate when reading a text, because if something is not understood at first, it can be reread. This finding is quite important, as during the design of the prototype a doubt had been installed as to whether simple textual information should be included in the guide.

Long dialogues were also held as to the kind of information the interpretation mean should provide, in terms of content. According to one participant the guide should *"set the good questions"*. According to another student a mobile guide should help on some aspects but leave free the visitor to trust his senses on others. In terms of content, while one participant explicitly mentioned that he would like to have something regarding the painting description, another participant of the same group implied that she does not need a description if she is watching a painting in real. So even in between the same group, positions, feelings and ideas about what the guide should include and how it should be presented were quite different.

This last remark was also validated by the fact that different content had different effects on subjects. More importantly, very often participants expressed themselves regarding favourite, interesting or less interesting themes included in all four paintings, while some participants seemed to navigate through the content following the same order in the activation of the themes (e.g. first choosing "artist", then "technique" etc).

Many other occasions revealed a diversity of opinions. For example, most of the audio sequences exceeded the 1.30" minute rule usually employed in museum audio guides. However, when visitors were asked their opinion as to the audio duration, only half of them found the audio content to be too long. Another personalization-related example related once again with the audio concerns the preference over a single or double headset. While most participants explicitly mentioned that they 'd prefer the latter, a female participant mentioned that she'd prefer a single headset as she is stressed whenever she is not in auditory contact with her surrounding environment. This justification is reasonable enough to be overseen, even if expressed by only one participant.

Apart from this manifested diversity of likes, dislikes and opinions regarding the prototype tested but also mobile multimedia guides in general, participants themselves also identified specific visitor groups for which specific attributes should be absent or present. A student for example, said that a guide destined to children should have a different approach than one for adults while another student underlined the importance of providing the guide content in several languages. As to the Fine Arts students group, a participant specified that as they already have foundations in approaching museum objects, they should be able to access a maximum of information in a minimum of time. Finally and also related with the issue of personalization or catering for the needs of specific visitor profiles, it should be noted that at least two participants answered they would use such a guide depending on the exhibition or the nature of paintings/objects included.

Finally, as we also saw in section 6.6.6, the most illustrative example as to the need for personalization is provided by our particular case study. Though qualitative and limited in sample, it became clear more than once, that the two different visitors' profiles examined demonstrated a different attitude and acceptance regarding the utility and the usability of the mobile AR guide in the context of a museum visit.

6.6.9 PROPOSED AMELIORATIONS ON THE TESTED AR PROTOTYPE

Some easy to implement ameliorations resulting from the feedback received during the evaluation sessions concern the modalities of the configuration delivery for the AR application. Alternative mobile platforms could equally be tested, as for example the SONY Vaio UX series presented in section 4.2.2. Meanwhile, the Orange Labs in Rennes have already received a new version of a SAMSUNG Origami Q1 which is lighter, has an integrated webcam and will be probably used in future experimentations. A neck strap could be attached so that future users do not fear an accident. It is also worth noticing that the use of the ARCHOS multimedia player with the attached head camera and microphone for the recording of the sessions caused also quite probably a discomfort to some of the participants that might have an impact on the proposed mobile AR experience.

A different issue that was detected on several occasions -though not foreseen- was related with the audio delivery. As we saw in section 5.4.4 because of the additional ARCHOS equipment carried by the participants but also in order to facilitate the observation, all audio sequences were delivered through the integrated UMPC speakers. During the observations it became clear that in periods of great visitor affluence in the museum galleries, participants had difficulties in listening the audio commentaries. Though the protocol and the research questions had not foreseen this issue, participants discomfort found its way through us, as the problem was mentioned spontaneously not only during the semi-structured interviews and the focus groups but also in open-ended questions of the survey. It is therefore clear that the audio should be delivered using headphones not only because of the poor performance of the integrated UMPC speakers but also as a courtesy to other museum visitors. Another issue related with the audio delivery, as pointed out by several participants, was the absence of a pause, forward and backwards button for the audio sequences.

In terms of interface a first necessary change is related with the touch-sensitive "freeze" button ("pause" in French). Its role was misunderstood several times (see section 6.2.2). An additional problem was highlighted by a male participant who said that as the UMPC has to be hold with both hands, it is quite difficult to disengage one hand so as to activate with the fingertip the "freeze" button. Some possible solutions regarding these problems could be to label the button with a more appropriate name, to render it larger so that as to enable an easier activation, or to use another device button in order to activate this function.

6.6.10 USERS PROPOSALS REGARDING NEW FUNCTIONS

Finally it could be interesting to resume in brief some functions that in their majority were first seen in Chapter 2 (section 2.2) but acquire here a particular interest as they were proposed as future add-ons by the students that participated in the Museum of Fine Arts in Rennes experimentations.

The first one, proposed by two different students in the two Focus Group sessions, is a "paint-it" application or -using the students of Fine Arts words- provide the possibility to *"transform the painting on the screen, like changing the colors",* but also be then able "…*to print that and take it home to have a small souvenir of what we did".*

Animating a painting's personalities and make them narrate their story was another idea that was proposed by a Social Sciences student. The way that was described was quite theatrical, with a female participant precising how she would animate the mouth of the depicted person and another one proposing to animate the full personality. Games regarding the paintings, especially adapted for children were also proposed during the 2nd Focus Group.

Other ideas that were discussed were the possibility to take personal notes regarding the painting, using the AR device, the creation of a virtual visitors' book where everyone could see the comments other visitors left regarding a painting and a photo-souvenir function, that would then transfer to the visitor's email address the captured pictures.

6.6.11 APPLICATION ACCEPTANCE AND POTENTIAL USER ADOPTION

Apart the variety of the issues discussed above, there also exists a category of factors that could difficultly fit in any of the above discussed sections.

For example the survey and the Focus Group provided evidence demonstrating that a high rental fee might be prohibiting for young people that might be positively predisposed for using the guide. Another reported dissuasive factor was visiting a museum together with a companion. For other students the choice would also be subject to the content of both the museum exhibition and the guide.

Lastly, the "must" and "must-have-not" attributes associated by participants to the ideal mobile museum guide during the focus group sessions are also quite informative. An ideal mobile museum companion should not be *"obligatory", "selective", "heavy in content" or "boring"*. To gain wide acceptance, it'd better be *"motivating"* but also *"relaxed", "educational"* and *"complementary", "playful", "surprising" and "amusing", "different"* or *"original", "curious",* and *"interactive", "practical"* and *"discrete", "subjective",* but also *"source of reflection",* and accessible *"to as many people as possible"*.

CHAPTER 7

CONCLUSIONS AND FUTURE WORK

7.1 SUMMARY

This thesis addressed the issue of introduction of mobile multimedia guides in the museum setting and suggested that the use of mobile AR technologies and the AR metaphor, as a principal component for the conceptual and interaction design of mobile museum guide applications, could greatly facilitate interaction and navigation both in a mobile multimedia application and in the sensitive museum environment.

Several steps were necessary before addressing the main research hypothesis through the design and evaluation of a mobile AR multimedia museum guide. An exhaustive state of the art for mobile museum guides was provided as well as a set of classification criteria with the goal to assist in establishing taxonomies but also in the presentation of the main functional requirements and the identification of principal issues mobile museum guide projects seek to address. The main human, economical and technological challenges and barriers to overcome were also highlighted in order to comprehend the reasons that have been so far preventing the generalization of use of mobile multimedia museum guides.

According to our main research hypothesis, the use and introduction of mobile Augmented Reality (AR) technologies and the AR metaphor, might provide a new, interesting alternative for assisting the visitor in the tasks of geolocalization and orientation both in the physical (the museum) and the digital (the mobile application) environment. This hypothesis was backed up both by the examination of current geolocalization methods as well as by a thorough analysis of the complex issue of interaction with mobile devices in the museum environment. As the visitor's attention gets fuzzily allocated among the museum guide and the surrounding environment (the museum object and other co-visitors), we suggested that, by "augmenting" the real, surrounding environment we assist the visitor in establishing clear, intuitive and straightforward links between the signifier (the digital multimedia application) and the signified (the museum objects on display).

In order to test this hypothesis, a mobile AR multimedia guide was designed, implemented and evaluated, using a user-centered approach, with the active participation of the state contemporary museum of Fine Arts, in Rennes, Brittany, France. After the creation and presentation of a first AR mobile museum guide prototype and the population of a comprehensive, potential functions list, a second AR prototype was designed and implemented in order to be tested in a real museum environment. A formal, extensive and qualitative in nature evaluation protocol was employed, shaped by several methodological considerations. The experimentations, consisting of direct and indirect observations, semi-structured interviews, the use of a survey and two focus group sessions, proved that AR has indeed the potential to be used as an intuitive and easy to understand alternative for geolocalization and orientation in the museum space and the mobile multimedia application, even by non-experienced IT users.

This chapter sums up the main conclusions resulting from the undertaken experimentations and other substantial methodological and theoretical contributions related both with the issue of mobile multimedia applications for the museum environment and the mobile AR character of the proposed application.

7.2 CONTRIBUTIONS

7.2.1 INTEGRATING AR IN MOBILE MULTIMEDIA MUSEUM GUIDES

Research problem: One of the most daunting tasks for a visitor during a museum visit is the correlation of the museum object contemplated with the relevant information provided by the selected interpretation medium, regardless of its nature (paper book, audio guide, multimedia kiosk, mobile museum guide). Especially regarding mobile multimedia museum guides, the issue of location awareness has proved to be of capital importance, as the visitors need to know not only how to "locate" themselves by navigating in the exhibition's physical space but also in the interactive application, as both actions occur at the same time. Therefore, two important questions museum visitors may pose themselves when using mobile multimedia museum guides are: a. Where can I find the object for which I can see there is relevant content? b. Where / how can I find information for this particular exhibition object I just happened to see? Both of these substantial questions share a common characteristic: they demand from the visitor to navigate from the digital to the physical space and vice versa (Damala et al., 2008).

Proposed approach: After examining the advantages and disadvantages of already existing geolocalization methods used in mobile museum guide projects, we argued that the use of a still emerging technology, AR, and the metaphor it introduces might worth to be considered as an interesting alternative for navigation and orientation both in the museum space as well as in the interactive multimedia content of the mobile museum guide. AR applications promise to extend the interaction in the real world surrounding us, by blending the real and the virtual and more particularly by overlaying computer generated graphics onto the perceived surrounding environment.

Evaluation: AR has already been used for cultural heritage related applications but has been scarcely proposed as an alternative method for geolocalization and orientation in mobile museum guide applications. Therefore, the first crucial test was to examine the ways AR could be integrated in mobile museum guides, through the population of a comprehensive function list, and then talk museum professionals **into** the interests of setting up a common project for evaluation in a real museum environment. The implementation of a first, working, AR prototype proved to be of great help, as it assisted in demonstrating the principle of mobile AR and the use it can have when integrated in a mobile multimedia museum guide.

7.2.2 USING AR FOR NAVIGATION AND ORIENTATION IN THE MUSEUM SPACE

Research problem: The first and most important principle a museum visitor needs to understand while using a mobile multimedia museum guide or any other interpretation material is how to correlate the signifier, the interpretation material provided by the mobile museum guide application, with the signified, i.e., the commented museum object on display. This task is further complicated by the fact that the user of the application, in our case the museum visitor, does not solely interact with a mobile multimedia application, but also with the surrounding museum environment as well as with other visiting companions in a fuzzy manner. The research question in this case is whether the use and integration of mobile AR in mobile multimedia guides can provide an alternative way for an easy and intuitive identification of the commented objects as well as a potential alternative for geolocalization and orientation. This way, instead of searching a point of reference on a digital, physically non-related with the environment, space, the museum visitor uses the real museum environment as a point of reference.

Proposed solution: Working closely with the museum representatives, a new mobile AR prototype, featuring 4 paintings, was designed and implemented before being evaluated in a real museum environment. The visitor uses a camera-equipped UMPC in order to "scan" the surrounding environment and detect, among many other non-commented paintings, the ones included in the multimedia tour.

Evaluation: The guide was tested by a test group consisting of 12 students, aged between 18 and 23 years old, using direct and indirect observations, semi-structured interviews, a survey, and two focus group sessions. The relevant findings of all evaluation phases proved that the task of localization and identification of the commented works in the museum galleries using the AR metaphor was straightforward, easy and intuitive for the large majority of participants. The only difficulty encountered by the participants, though only at the beginning of the tour, was to understand that in order to make the virtual overlays to appear, the paintings had to be visible by the camera in their full height and length.

7.2.3 USING AR FOR NAVIGATION IN THE CONTENT OF THE APPLICATION

Question: Apart from using AR for the identification of the included in the mobile museum guide paintings, the AR metaphor was also consistently used for navigation in the interactive content of the application. The question in this case was whether the navigation scheme, also based on the AR metaphor, was easy and intuitive to understand.

Proposed solution: The navigation in the mobile museum guide application was consistently built on the AR metaphor. When a painting is located, a visual and audio alert is produced to indicate that a painting has been found, while when the visitor approaches closer a new interactive menu appears on the display of the UMPC screen around the identified painting, composed from virtual overlays, each representing a particular theme. When a theme is activated, new virtual overlays in the form of pictograms (representing data in form of text, audio, slideshow or video) are arranged around the commented painting.

Evaluation: The quantitative and qualitative results demonstrated that the navigation scheme was very well understood. The findings from the semi-structured interviews in which the issue was brought up were in accordance with the findings of the observations, and the survey results; all students either strongly or somewhat agreed with the "easiness of navigation" statement. Additionally, during the Focus Group sessions, many participants were capable of describing in detail the way they navigated in the application proving retention of the navigation scheme over time.

7.2.4 THE NEED FOR PERSONALIZATION AND CUSTOMIZATION OF APPLICATIONS AND SERVICES

Question: Personalization and customization is a much discussed concern regarding mobile devices and services which acquires an even greater importance in the museum environment, by definition open to a public of different ages and backgrounds. While personalization has been studied in many instances in relation to museum web sites, personalization concerning mobile museum guides is still far from being adequately explored. Though the experimentation in the Museum of Fine Arts had not explicitly set as a primary goal examining the need for personalization, the evidence that came to light proved to be very informative as to this issue.

Proposed Answer: Apart the diversity of answers obtained by the participants as to their visiting habits, the use of interpretation material and the frequency of visit, the content of the mobile guide and the media used did not have the same effect on all participants. An illustrative example is that though almost all participants had a strong or moderately positive attitude as to whether the guide helped them better approach the paintings and admitted that they would use it if available in a museum, the group of occasional museum visitors seemed to appreciate more using the guide and felt more confident as to whether they learned more in comparison with the group of frequent museum visitors. Many other occasions revealed a diversity of likes and dislikes (for example, though many of the audio sequences exceeded the 1.30" average audio comment duration, only half of the participants found them to be too long), demonstrating that the new possibilities opening up regarding the personalization of content and services respond to an actual need.

7.2.5 PUTTING THE EXPERIMENTATION METHODOLOGY ON THE BENCHMARK

Research Question: Given the scarcity of mobile AR evaluation and user-centered studies and the absence of any study regarding the integration of mobile AR technologies for mobile guides in the museum setting, a research issue that emerged was not only to come to some conclusions as to the suitability of the experimentation methodology and the adopted experimentation protocol but also to backup and demonstrate the need for user-centered design and evaluation of mobile AR applications.

Answer: Due to the lack of evidence from relevant experimentations, our evaluation protocol favored an exploratory in nature study, mainly qualitative in nature. The combination of four different evaluation methods (observations, semi-structured interviews, survey, and focus groups) was proved to be more than well suited for the research carried out, as it allowed not only the triangulation of the results, but also the detection of issues that would have otherwise remained undetected (for example, the problem caused by the "freeze" button and the problems related with the audio delivery).

Another remark of particular interest was that the interactive multimedia content that benefited most from the interdisciplinary collaboration with museum professionals came on the top of the test group preferences, thus validating our approach of working, from the very beginning, closely with all of the involved stakeholders. Other findings also established the significance of implicating potential users earlier in the design process: the experimentation participants demonstrated ability in captivating the essence of the experimentations and the AR approach, offered useful input for future functions to be embedded and managed to express themselves as to potential ways of interacting with more advanced and innovative AR applications. Finally it should be noted that these findings were detected using a relatively small test group consisting of 12 students, proving thus that even small scale user-centered design and evaluation can provide very useful insights.

7.3 A CRITICAL APPRAISAL OF THE AR APPROACH

Employing a cutting edge technology, largely still under development, for the implementation of a mobile multimedia application does not come without a certain cost. And even though the research hypothesis as to whether AR can provide an interesting alternative as an interaction component for mobile multimedia museum guides was confirmed, it would be an omission not to look further into some important issues that raised our concerns, during the full life circle of the proposed intervention.

As already discussed in Chapter 3, AR applications rely heavily on accurate, fast and robust tracking mechanisms. Especially for mobile AR applications this need is even more imposing, as the context of use of the application cannot always be controlled. Despite the fact that the indoor museum space can be qualified as much more easy to control in comparison with other indoor or outdoor environments, at the time of the experimentations, the algorithms developed were not robust enough so as to detect all museum paintings. As a consequence, museum curators were extremely restrained regarding the content selection and were obliged to choose among a preselected test group of easily and robustly recognized by the system paintings.

Another important difficulty was that, as AR applications are still far for creating a mass market success, potential users, in our case the museum representatives, are rarely aware of the modalities of the technology and find very difficult expressing their needs in terms of AR scenarios as well as anticipating ways with which AR applications could be used in their setting. This was also an additional reason for which the interdisciplinary collaboration necessitated for mobile museum guide projects was even more intensive in the case of the Museum of Fine Arts in Rennes project.

The very same reason also created difficulties in the evaluation phase. Mobile AR had to be put on the benchmark, as an alternative solution for geolocalization, orientation and navigation. However from the very beginning, it was clear that this question was not possible to be answered in an absolute manner; neither the museum nor the test group had any experience regarding AR applications, or mobile multimedia guides used as an interpretation resource in the museum setting. This consideration had a clear impact on the evaluation methodology and the evaluation protocol finally adopted for the experimentations.

Finally, the most important constraint is related with the nature, the potential and the aspirations of mobile AR technologies, promising to embed interaction right where it belongs, in the real environment surrounding us, freeing us from the conventional interaction with WIMP (Windows, Icons, Menu, Pointing devices) interfaces. However the current state of the art in Mobile AR applications is still quite far from this perspective. Looking closer to our case study, we were lacking the possibility to provide our test group with a platform-free AR experience, proposing for example a lighter, more discrete, more futuristic display so as to completely liberate museum visitors from a quite heavy and impossible to manage without using both hands, equipment.

7.4 FUTURE WORK WITHIN A SHORT-TERM HORIZON

The work carried out during this thesis formed part of a proposal directed to the French National Research Agency in the 2007 selection, regarding the creation of a mobile augmented reality guide for the Museum of Fine Arts in Rennes. The project proposal was successful, so we can consider that from January 2008 and for 30 months (until mid 2010) our case study entered a new phase of development and experimentations.

The new guide, largely based on the prototype we examined and evaluated, will target young people between 15-25 years old and will be first available on a UMPC platform, while at a second phase it will be also proposed on smart phones. New and more robust algorithms will be developed and integrated while the vision based tracking and pose estimation method used for the examined by the thesis prototype will be also enriched through the use of specific sensors (e.g. magnetometer, accelerometer). In terms of content, the new prototype will also integrate animated 3D objects and avatars and navigation information allowing visitors to find their way in the museum galleries. Therefore, the minor contribution as to this new phase of experimentations would be to highlight some interesting research directions.

7.4.1 IMPROVE THE GRAPHIC AND INTERACTION DESIGN

A substantial part of the feedback generated by the evaluation process was relevant with the graphic and interaction design of the application. The feedback was relevant with missing functionalities (e.g. the absence of controls for the audio), poor user performance in some critical tasks (e.g. understanding the role of the "freeze" button or failure to easily activate) or not clear enough and attractive graphic design (e.g. the pictogram used for the slideshow presentations and the overall "look and feel" of the graphic design, particularly criticized by the students of Fine Arts). In addition many participants mentioned not approving the audio delivery through the UMPC speakers and expressed their wish to have the possibility to "put away" the guide whenever they feel the need to. All these remarks can be easily taken under consideration in the design and implementation of the new prototype.

7.4.2 PROVIDE A CONTENT AUTHORING TOOL

Content creation and authoring is a time, money and energy consuming process for most mobile museum guide projects. However, in our case study, the introduction of a still emerging technology, mobile AR, complicated this task even further. The content authoring process that took place after the process of content creation occurring through close collaboration with the museum representatives was extremely long (approximately 7 to 8 man hours per painting) and was entirely confided to the IT stakeholders. The creation of a content authoring tool could not only decrease the time needed to create the multimedia presentations, but also enable museum curators and educators themselves to create their own content.

7.4.3 IMPLICATE THE TARGET GROUP EARLIER IN THE INTERACTION DESIGN PROCESS

Despite the fact that the sample used for the validation of the mobile AR museum guide prototype was not large, due to the exploratory nature of the study and the technological immaturity of the evaluated prototype, several intriguing ideas regarding new applications and new ways of interaction, came to surface during the evaluation. At the same time the evaluation process proved that the test group was not only very attentive and critical but also very demanding. Introducing participatory design and implicating selected representatives of the target group in earlier stages of the life circle of the project could provide meaningful insights and further enhance the potential user acceptance of the new prototype.

7.4.4 EXPERIMENT WITH LESS INTRUSIVE DISPLAYS

As already mentioned in the critical appraisal of the AR approach, one of the most influential constraints regarding the AR approach of our mobile museum guide prototype, was the UMPC terminal and display used. Given that the 2nd phase of the new project plans to deliver the tour also on a MID (Mobile Internet Device) platform, several new potential directions open up. The first one would be to compare the acceptance of the UMPC delivered museum tour versus the MID delivered one. Secondly, delivering the tour on smart phones will render comparisons with other already existing PDA tours easier. Finally, until mid 2010, it might be possible to envision the feasibility of experimentations that would use a MID or smartphone as a delivery and computational platform but a pair of AR goggles as a display. That would not only free the hands of the participants but also the imagination of the users and the involved stakeholders regarding new possible ways of interaction with mobile AR applications in the museum context.

7.4.5 EXPERIMENT WITH NEW FUNCTIONS

Regardless of whether it will finally be possible to free from material constraints the targeted users of the application, the evaluation of the proposed AR prototype identified -through a close and long collaboration with the recruited participants- several new functions possible to be embedded in the new AR prototype. Among them, a notes-taking function, several personalized souvenirs functions and a virtual guest book function coupled with a spatial annotation function that would give the visitors the possibility to spatially annotate paintings and museum objects. Some of these new functions are already considered for inclusion in the next AR prototype, as for example the "paint it" function that has been already implemented and integrated in the guide and now needs to be validated.

7.4.6 VALIDATE AND FURTHER DELVE INTO THE RESULTS OF THE FIRST EXPERIMENTATIONS

The evaluation phase shed light on several anticipated and unanticipated issues, such as visitors' acceptance of the proposed mobile museum guide application, visitors' satisfaction regarding the content delivered or the role personalization and customization may exercise in the overall user experience. However, the results of the evaluation phase also brought to light new issues that should be further investigated in the forthcoming evaluation phases. Are there additional reasons for which occasional museum goers enjoyed more the proposed application, in comparison with frequent museum goers? Is the term AR or the technology itself that provoked explicit affective reactions, observed during the focus groups and one of the survey questions? Are there other explanations for which the word "playful", attributed under many circumstances to the guide, was employed by the participants both with a positive and negative connotation? Are there any correlations between the use of mobile AR and the issue of attentional balance and user distraction detected, or is this problem simply correlated with the principle of introducing a mobile multimedia guide in the museum environment? These are only some of the questions that could be further explored in the next AR prototype evaluation sessions. Finally, given the fact that the evaluation carried out was qualitative in nature, a cross-checking of the reported results could also be of strong interest.

7.5 FUTURE WORK WITHIN A LONG-TERM HORIZON

Apart the above mentioned short-term horizon research axes, several new directions, both regarding the use of mobile multimedia museum guides and mobile AR applications are worth to be explored more in depth, within a long term horizon. The main axes which are closely related to our work are examined in this section.

7.5.1 INTRODUCING A LESS TECHNOCENTRIC, VISITOR-ORIENTED DESIGN APPROACH

As we had the chance to see in several occasions, mobile museum guides should not be considered as a new-age gadget but as an additional, interactive interpretation medium to be used alongside other existing museum interpretation media. However, often enough museum professionals express their fears as to the impact the use of a mobile museum guide could have in the relation developed between a museum visitor and an exposed museum object. Despite the care undertaken in the conceptual and interaction design of the Museum of Fine Arts in Rennes mobile museum guide, evidence coming from the experimentations proved that such an issue does indeed exist. How could one cope with this issue, both regarding museum professionals but also the target group of the application, meaning museum visitors?

Encouraging and enforcing an even more user and visitor-oriented design approach might be a solution to this problem. More concretely and towards this direction, the research carried out lays some first foundations by:

A. Defining current deadlocks to overcome and future challenges as to the introduction of mobile guides in the museum environment that were subsequently classified under three categories, human, economical and technological.

B. Proposing a new framework for examining the interactions that occur during a mobile museum guide escorted visit, introducing seven different interaction variations involving the museum visitor, the mobile guide, other co-visitors and the museum environment. This approach allows for a better comprehension of the action-space as well as of the elements that differentiate MHCI with mobile museum guides as in contrast with other mobile, interactive, multimedia applications.

C. Establishing criteria for the classification of mobile multimedia museum guides in order to more effectively identify possible functional requirements but also in order to tackle down the main issues a mobile museum guide project seeks to resolve.

D. Populating an inventory of possible mobile museum guide functions so as to identify needs, establish requirements, better understand the nature of the "problem-space" context and lay the foundation for user task analysis.

E. Introducing a generic evaluation taxonomy scheme for front-end, formative or summative evaluation, defining three categories of evaluation issues susceptible to arise during the evaluation and assessment of a mobile multimedia museum guide that may serve as a guide for planning and conducting evaluation sessions.

As the main research question was the use of AR technologies and the AR metaphor in mobile museum guides, these user-centered directions need further confirmation and validation.

7.5.2 TAKING UNDER CONSIDERATION THE SOCIAL CHARACTER OF THE VISIT

Several recent studies have proved that museum visiting is in most cases also an activity of social character, especially among non-frequent visitors for whom sharing the visiting experience may obtain a greater importance than the educational aspect of the museum visit itself (Hurst et al., 2002, Hood, 1983). In parallel, an increasing number of cultural institutions are striving to involve museum visitors in a public dialogue around ideas and exhibits.

Therefore, the possibilities of integration of communication services, edutainment activities or modules that could link the pre-, during- and post-visit phases acquire a particular meaning that is still not adequately explored, especially taking under consideration the change that has occurred in instant, direct, real-time and on-the-go communication among a population exponentially more familiar with mobile devices and communication services. Another possible future research direction, still barely explored, is the provision for application modules that would allow linking outdoor and indoor cultural activities. This scenario acquires even more importance in the case of archeological sites whose findings are exposed in nearby museums. Educational games and activities could also be of benefit for school groups or visiting families.

7.5.3 CONCEIVE A DEDICATED PLATFORM

The experimentations in the Museum of Fine Arts in Rennes used a UMPC device for the application delivery, among other reasons because the available interaction surface is larger than the one provided by PDAs which are today the most widely used devices for the delivery of multimedia museum tours. However neither of these two platforms may be considered to be ideal for the examined type of application. In this thesis, several possible current and future displays were examined, but at this time there exists no specific device or display for the delivery of a multimedia museum tour. A first step towards that direction would be to discuss and establish requirements by implicating IT specialists, museum professionals and museum visitors. The only existing example of a specialized mockup was presented in (Kondo et al., 2007), but undeniably the initiation of a dialogue around this topic could not only assist in establishing requirements but also in convincing IT companies and professionals that the design and implementation of a dedicated platform is an issue that is worth to be investigated.

7.5.4 FURTHER EXPLORE HUMAN COMPUTER INTERACTION WITH MOBILE AR APPLICATIONS

The issue of candidate delivery platforms is central not only for mobile multimedia museum guides but also for mobile AR applications as it is very closely related not only with the level of immersion in mobile AR applications but also with the discovery of new ways of interaction with the proposed AR systems. The conceptual design and implementation of a dedicated mass-market, light-weight and low-cost mobile delivery platform could unleash the hidden potential of mobile AR applications and bring us closer to the discovery of new ways of interacting not solely with and "augmented" device or display but with an augmented environment.

However until then, a number of necessary steps should be taken in order to establish AR-specific design guidelines through assessment, evaluation, participatory and user-centered design. This is a fundamental step as evaluation and user-centered design seems to be still largely underestimated among the AR community while even when users are early enough implicated in the design process, they have difficulties in expressing their needs in terms of AR scenarios as they are not sufficiently aware of the technology's potential. Re-placing the user, in our case the museum visitor, on the center of the focus of the AR community might eventually assist in establishing design and evaluation guidelines for mobile AR applications. As demonstrated by the experimentations in the Museum of Fine Arts even exploratory and medium scale evaluation can provide useful insights regarding the acceptance of mobile AR applications and reveal unanticipated outcomes, as was the case with the strong affective reactions provoked to our test group by the use of the term "Augmented Reality".

Finally another minor theoretical and methodological contribution regarding AR was also expressed, necessitating further validation and feedback from the related communities. More in particular, we proposed an alternative apprehension of AR technologies concentrating on the nature of the object to augment, instead of concentrating on the ways of augmenting an object, as proposed by a widely cited article of 1998 (Mackay, 1998). Examining the "what" and not the "how", we concluded that an AR application can either a) replace/render a physically non existing object or b) Visually supplement an existing physical object. Further on, examining the type of allowed interactions, the second category can be further decomposed in AR applications in which: 1) the augmentation can be manipulated through interaction with the physical object, 2) the physical object can be manipulated through interaction with the augmentation, 3) only the augmentation and not the real object can be manipulated. This apprehension of AR could assist in a more effective understanding of the "problem space" and the enunciation of the most appropriate per case interaction and implementation solutions.

7.5.5 ELABORATE CONTENT AUTHORING TOOLS

As we already saw in section 7.4.2 one of the goals of the GAMME project currently -and until mid 2010- under development is the creation of an AR content authoring tool. Content creation and content authoring are two major procedures in the life circle of augmented and more "conventional" mobile museum multimedia guides. In this thesis we defined as content creation the process of scenario and educational resources development, mainly accredited to museum curators and educators, and as content authoring the stitching of all the produced by content creation material into a meaningful, attractive and coherent multimedia presentation.

However, almost all of the commercial solutions proposed (with the exception of two according to the author's knowledge) do not propose any kind of tools that could facilitate museum curators and educators in creating, elaborating and implementing their own educational scenarios. This renders the content application difficult to manage, as for the slightest change or addition, the content has to be re-authored by IT professionals. This way of proceeding not only alienates museum professionals from the final application but also stretches the necessary time needed from the conception to the design and implementation of a multimedia guide. In addition already existing IT applications or digitized educational material cannot be relayed or connected with the mobile museum guide application. A more meaningful solution would be to create a system that would allow interconnections between the museum documentation and interpretation databases and/or other IT applications used for the interpretation of cultural heritage. The problem becomes even more complicated when mobile AR enters the scene, as at the time of writing, there exists no easy to handle content authoring tool for AR applications. In conjunction with the problem of robust, fast and accurate tracking, the situation seems to present many inherent difficulties.

7.6 ON THE FINISHING LINE

The work carried out during this thesis was the result of interweaving multiple projects, approaches and disciplines and benefited from long and extensive collaborations with professionals of different backgrounds; professionals that quite probably, under other circumstances might have never been met, collaborated or joined forces. This aspect, dictated by the interdisciplinary nature of the research topic undertaken, was also one of the most challenging during these four years and not always easy to cope with.

This is also why this adventure has also been so rewarding, hopefully not only for the author, but also for other partners, persons, projects or institutions that actively contributed to the elaboration of what at the beginning seemed a peculiar and weird idea to a legitimate research hypothesis worth to be investigated during PhD thesis project: integrating mobile AR technologies in a mobile multimedia museum guide. It was mainly the 1st component combined with the 2nd one that constituted a real challenge; at the time that this work was undertaken no similar effort or case study was known to exist, at least in the museum context.

Though this work demonstrated that mobile AR is worth to be considered as an adequate and intuitive alternative for geolocalization, navigation and orientation in the museum environment, the author believes that much time (not less than 5 years) will be needed before we witness a more generalised introduction of mobile AR guides in the museum environment. The technology needs to get more mature, the equipment more affordable and the scientists more user-oriented before attempting to introduce at a larger scale AR in mobile multimedia museum guidance systems. But this is not necessarily a compromising constraint, as in the meanwhile mobile multimedia guides will have much more penetrated the museum setting and will be on their way of becoming the rule rather than the exception. Museum professionals will be more at ease with the idea of introducing this alternative interpretation medium as a standard offer among other well established and known practices (guided tours, multimedia kiosks, guided visits etc); the public will be even more accustomed in manipulating mobile multimedia devices and services, even during a museum visit. And it is probably at that time that certain dimensions and findings of the undertaken work will be possible to be authentically assessed and cross-checked; provided that we stayed focused on the objective rather than the technology.

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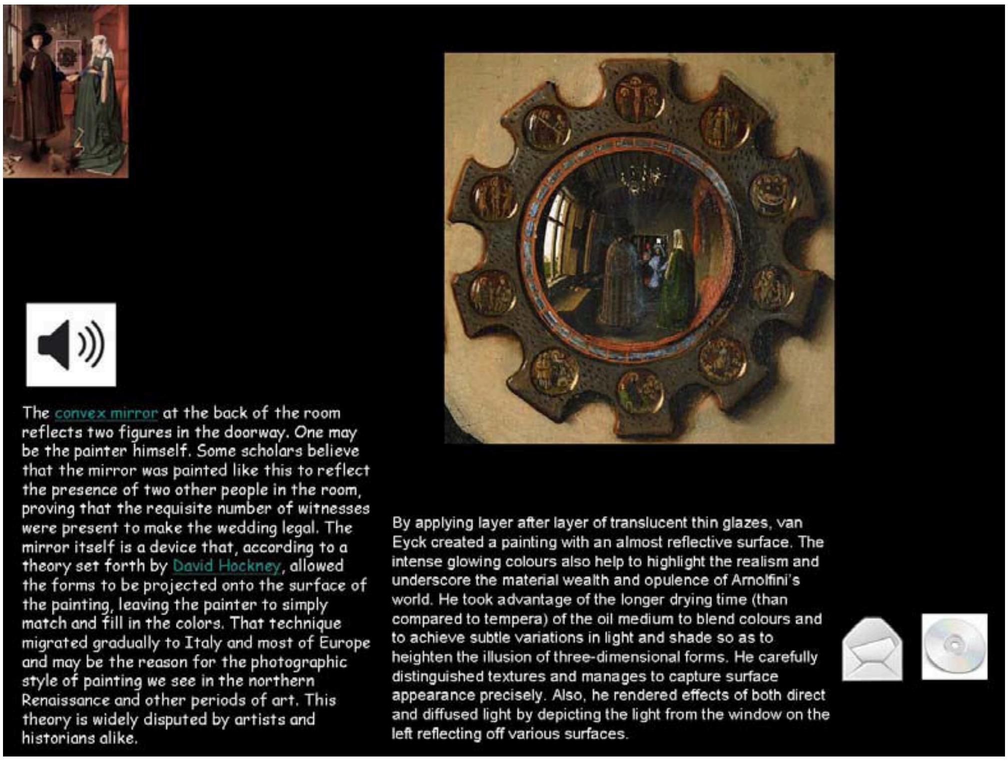
APPENDICES

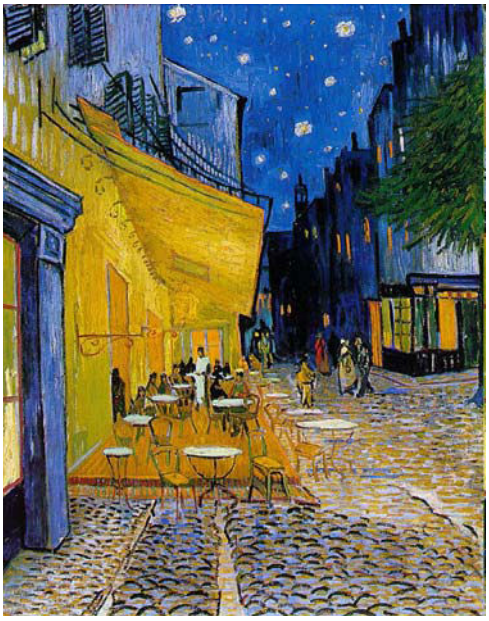
APPENDIX I: THE 1ST AR PROTOTYPE

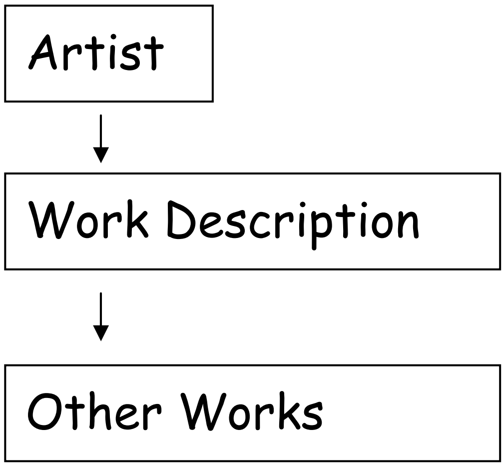
A. MOCKUPS CREATED FOR THE 1ST AR PROTOTYPE



B. SOME OF THE CONTENT CREATED FOR THE 1ST AR PROTOTYPE

Vincent van Gogh, The Cafe Terrace on the Place du Forum, Arles, at Night, Kröller-Müller Museum in Otterlo, Netherlands, 1888,





1. Title, Artist, Date, Place of Exhibition

Vincent van Gogh, The Cafe Terrace on the Place du Forum, Arles, at Night, Kröller-Müller Museum in Otterlo, Netherlands, 1888
Oil on canvas, 81.0 x 65.5 cm

[This info figures on the mobile device as soon as the painting is detected, and stays activated throughout the full tour]

2.Artist biography

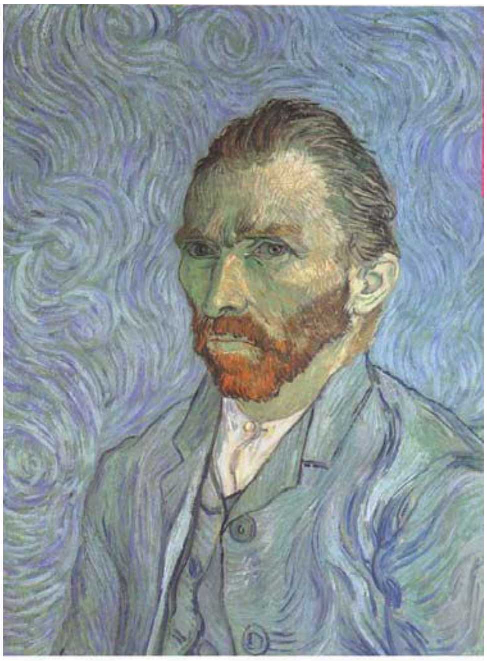
AUDIO [female voice]: ***Vincent Willem van Gogh*** *was a Dutch and painter, classified as a Post-Impressionist. His paintings and drawings include some of the world's best known, most popular and most expensive pieces. He produced all of his more than 2,000 works, including around 900 paintings and 1100 drawings or sketches, during the last ten years of his life. Most of his best-known works were produced in the final two years of his life, and in the two months before his death he painted 90 pictures.*

He suffered from recurrent bouts of mental illness — about which there are many competing theories — and during one such episode, famously cut off a part of his left ear.

ACCOMPANYING IMAGES (during this narration):

A. Photo of Van Gogh at a young age

B. Self portrait



Van Gogh: Self-Portrait

3.Painting description

AUDIO [female voice]: Vincent van Gogh's The Cafe Terrace stands as one of the painter's most remarkable works. It is also, without question, one of the most famous produced in Van Gogh's brief but prolific career. *Vincent was enthusiastic about The Cafe Terrace and wrote to his sister Wil:*

AUDIO [male voice]: *"In point of fact I was interrupted these days by my toiling on a new picture representing the outside of a night cafe. On the terrace there are tiny figures of people drinking. An enormous yellow lantern sheds its light on the terrace, the house and the sidewalk, and even causes a certain brightness on the pavement of the street, which takes a pinkish violet tone…Here you have a night picture without any black in it, done with nothing but beautiful blue and violet and green, and in these surroundings the lighted square acquires a pale sulphur and greenish citron-yellow colour. It amuses me enormously to paint the night right on the spot…"*

[The café]

AUDIO [female voice]: *More than one hundred years after Vincent painted it, the Cafe Terrace is still in Arles serving drinks to its thirsty patrons. It's now called the Cafe Van Gogh, appropriately enough, and has been remodelled to appear as it did more than a century ago.*

ACCOMPANYING IMAGES (during this narration):

A. The Café today

B. The Arles café as painted by van Gogh in 1888

4.Comparison with other works (Starry Nights)

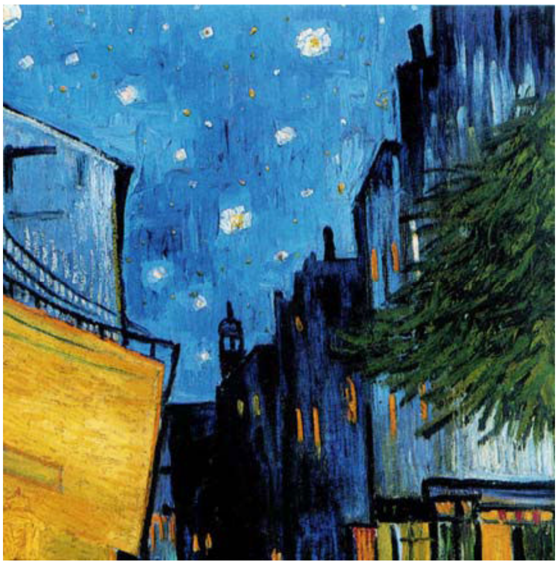
AUDIO [female voice]: *This work is the first in a trilogy[1] of paintings which feature starlit skies. Starry Night Over the Rhone came within a month, followed by the popular Starry Night painted the next year in Saint-Rémy, today in the museum of Modern Art in New York.*

ACCOMPANYING IMAGES (during this narration):

A. Detail of Arles café starry sky

B. Starry Night Over the Rhone

C. Starry Night in Saint-Rémy



5.Comparison with other works

A. Potato eaters

AUDIO [female voice]: ***The Potato Eaters*** is a well known early work of Vincent van Gogh that he painted in April 1885 while in Nuenen, Netherlands. It is housed in the Van Gogh Museum of Amsterdam.

AUDIO [female voice]: Van Gogh said he wanted to depict peasants as they really were.

> **AUDIO [male voice]:** *"I wanted to convey the idea that the people eating potatoes by the light of an oil lamp used the same hands with which they take food from the plate to work the land that they have toiled with their hands— that they have earned their food by honest means".*

AUDIO [female voice]: He deliberately chose coarse and ugly models, thinking that they would be natural and unspoiled in his finished work

ACCOMPANYING IMAGES (during this narration): The potatoes eaters

B. Bedroom in Arles

Bedroom in Arles is the title given to each of three similar paintings by Vincent van Gogh.

AUDIO [female voice]: Van Gogh's own title for this composition was simply *The Bedroom*. There are three authentic versions described in his letters, easily discernible from one another by the pictures on the wall to the right. The painting depicts Van Gogh's bedroom at 2, Place Lamartine in Arles, Bouches-du-Rhône, France, known as his Yellow House. Van Gogh started the first version mid October 1888 while staying in Arles, and explained his aims and means to his brother Theo:

The bedroom in Arles

AUDIO [male voice]: *Well, I have thought that on watching the composition we stop thinking and imagining. I have painted the walls pale violet. The ground with checked material. The wooden bed and the chairs, yellow like fresh butter; the sheet and the pillows, lemon light green. The bedspread, scarlet coloured. The window, green. The washbasin, orangey; the tank, blue. The doors, lilac. And, that is all.*

ACCOMPANYING IMAGE (during this narration): The bedroom in Arles

APPENDIX II: SCRIPTS OF THE 2ND AR PROTOTYPE (MUSEUM OF FINE ARTS IN RENNES)

A. SIMPLE TEXT SCRIPT

Georges LALLEMANT,
[Nancy, vers 1575 – Paris, 1636]
La Sainte Famille, première moitié du 17e siècle,
Huile sur toile
115 x 94 cm
achat, 1989
inv. 89.2.1

Elève de Simon VOUET, peintre et graveur, Georges Lallemant est né dans le duché de Lorraine, foyer artistique alors dominant en Europe. On ne connaît de lui qu'une quinzaine de toiles sûres, peintures d'histoire, portraits, sujets religieux, récemment réévalués par des historiens de l'art.

Il fut l'un des artistes les plus renommés du commencement du règne de Louis XIII comme en témoignent les commandes que lui passe la confrérie des Orfèvres en 1630 (le "Mays" de Notre-Dame de Paris). Dans l'histoire de l'art, on peut dire qu'il a été victime d'un phénomène de mode: son art maniériste a été effacé par celui des classiques de la génération suivante dont les plus grands, Philippe de Champaigne, Nicolas Poussin, Laurent de La Hyre ont pourtant fréquenté son atelier.

Les "petits mays" portent le nom d'une manifestation organisées par la communauté des Orfèvres au mois de mai dans la cathédrale de Paris, entre 1609 et 1629. Ils étaient constitués d'un tabernacle en bois sculpté, triangulaires et portant de chaque côté 3 petits tableaux enchâssés: l'un figurait habituellement une scène de la vie de la Vierge, sur les deux autres on pouvait lire des poèmes expliquant le sujet et offrant des louanges à la Vierge. L'ensemble était suspendu dans la nef de la cathédrale comme en témoigne un tableau du 17e siècle conservé au musée de Notre-Dame.

De Georges Lallemant, nous connaissons un autre *Petit May*, *Saint Pierre et saint Jean guérissant le paralytique à la porte du Temple*, conservé à l'église de Saint-Chéron dans l'Essonne.

(1) Description

Au premier plan, une femme, vêtue d'une robe rouge flottante et d'un manteau bleu tient un linge blanc sur lequel est posé un tout jeune enfant aux cheveux blonds. Ces différents attributs confirment qu'il s'agit d'une représentation de la Vierge et de l'Enfant Jésus, ils sont entourés de Joseph et de l'Ange et forment la Sainte Famille. La figure centrale de la Vierge est accentuée par le volume de sa coiffe, qui lui tient lieu d'auréole. A l'arrière plan sur la droite, Joseph, d'un air placide observe la scène tandis que sur la gauche, à l'arrière plan également, l'Ange fait un geste protecteur vers la mère et l'enfant.

(2) Analyse technique

La composition de cette scène transmet une impression d'étrangeté à plusieurs degrés. Le visage de la Vierge plonge dans la pénombre selon un raccourci qui semble spécifique au peintre. On retrouve en effet cette "manière" dans une œuvre antérieure, conservée au musée de Varsovie, *Georges prompt à la soupe* (Figure A).

Les personnages sont rassemblés dans une proximité spatiale très resserrée. Les proportions telles qu'elles sont attribuées aux figures restent arbitraires ; ainsi, les personnages de Joseph et de l'Ange semblent très en retrait par rapport à la figure centrale de la Vierge. Enfin, les drapés sont envahissants. Ce sont là les traces d'un maniérisme finissant.

Le laboratoire de recherche des musées de France, en 1989, avait effectué une série d'examens de l'œuvre.

L'examen dans l'infrarouge a mis en évidence un léger repentir sur le profil de l'ange. Il restitue l'ampleur initiale du voile de la Vierge, retombant sur son épaule, rendu peu perceptible par un coup de pinceau ancien qui assombrit le vêtement de l'ange (Figure B).
La fluorescence ultraviolette (non disponible aujourd'hui) montre de nombreux repeints récents, excessifs par rapport à l'état de conservation satisfaisant qui a révélée la radiographie.

Jusqu'à récemment, sous couvert de restauration et de conservation, on a ainsi modifié légèrement l'intégrité de certaines œuvres.

(3) Iconographie

La représentation de la Sainte Famille est déclinée en abondance à travers l'histoire de l'art en Europe. Les rares sources bibliques connues proviennent de quelques versets de l'évangile de Matthieu. Emile Mâle a évoqué l'importance des récits apocryphes pour l'art médiéval. Ici, le sujet reste très libre, mettant en évidence la Vierge et l'Enfant, les personnages de Joseph (très pensif) et de l'ange se déployant davantage comme des figures décoratives destinées à consolider la composition.

(4) Contexte d'apparition de l'œuvre

Le style maniériste, quoique tardif, est reconnaissable dans la composition de ce tableau qui se traduit par une impression d'étrangeté dans la composition. Les personnages sont rassemblés dans une proximité spatiale très resserrée, les proportions attribuées aux figures restent arbitraires et les drapés envahissants.

Le visage de la Vierge plonge dans la pénombre selon un raccourci spécifique au peintre. On retrouve en effet cette "manière" dans une œuvre de l'artiste, conservée au musée de Varsovie, *Georges prompt à la soupe*.[trouver la photo ?]
La robe plissée de la Vierge occupe une partie importante de la composition et répond en contrepoint à l'ellipse des langes de l'Enfant. La coiffe qui tient lieu d'auréole est dite "à la bohémienne" que l'on retrouve chez Claude Vignon.

Les traits de la Vierge doivent être rapprochés de ceux du Christ de la chapelle Saint-Nicolas-des-Champs de Vic, permettant de dater plus précisément l'œuvre : 1621 (Figure C).
Rapprocher le dessin du Louvre de *La Sainte Famille*, exécuté en 1623 semble-t-il : les deux enfants sont très proches dans leur facture.

B. ILLUSTRATED TEXT SCRIPT

La femme entre les deux âges, Anonyme français, XVIème siècle, vers 1575

(1) Description

La femme entre les deux âges

Peintre anonyme français, vers 1575

La datation de ce tableau est approximative, le titre a été donné à une période récente et le peintre nous est inconnu... Nous ignorons aussi à qui appartenait l'œuvre avant son entrée dans les collections, au tout début du XIXème siècle. Le raffinement des costumes et l'érotisme de la scène rappelle aussi le style de l'Ecole de Fontainebleau né à la cour de François Ier, quarante ans plus tôt, sous l'influence de quelques peintres italiens.

Mais si l'histoire du tableau demeure mystérieuse, le thème représenté est très fréquemment traité dans la deuxième moitié du XVIème s.

Le Musée de Rennes possède d'ailleurs une version très proche dans laquelle la jeune femme est habillée.

La femme entre les 2 âges, Musée de Beaux Arts de Rennes

Il existe également une gravure anonyme conservée à la Bibliothèque Nationale, accompagnée du poème suivant :

Ecole française du 16eme siècle, la femme entre les deux âges, gravure, collection de la bibliothèque nationale

"Voyez ce vieux pénard, enveloppé dans sa mante
Les bras croisés gémir ce qu'il veut et ne peut.
La belle gentiment de deux doigts lui présente
Ses lunettes disant que grand tort il se **deut**
D'ailleurs rend son mignon plein d'une amour plaisante,
Serre son petit doigt et veut tout ce qu'il veut.

Bonhomme, tenez vos lunettes
Et regardez bien qui vous n'êtes
De l'âge propre aux jeux d'amours
Un chacun cherche son semblable
Souffrez qu'un autre plus valable
Cueille le fruit de mes beaux jours.

Trois personnages occupent le premier plan: à gauche, un couple, à droite, un vieil homme.
Le peintre donne très peu de détail sur le contexte de la scène. L'architecture suggérée lui permet surtout, par le tracé d'une ligne de fuite avec la corniche, de suggérer une profondeur.

(2) Analyse Technique

Les couleurs choisies dans les gammes sombres mais assez chaudes pour le vêtement des hommes mettent en valeur la carnation du corps féminin soulignée par la transparence blanche, plus froide, du voile.
Un examen attentif de la toile montre des reprises très importantes et une patte différente beaucoup plus épaisse sur les cotes gauche et droit du tableau ainsi qu'en haut. Doit-on y voir une modification du format de l'œuvre? Seul un examen radiographique l'assurerait. (Plaquette pédagogique)

(3) Analyse du Sujet

La jeune femme attire notre attention dès notre entrée dans la salle. Parce qu'elle est le seul personnage de face, par la nudité et la pâleur de son corps. Et, bien sûr, par le regard qu'elle nous adresse et qui nous suit, où que nous soyons dans la salle. Le voile qui la couvre laisse voir, il révèle plus qu'il ne cache. Comme ses bijoux, il met en valeur un corps. Par un léger déhanché, la jeune femme s'appuie contre son amant. Entre le pouce et l'index droits, elle serre son petit doigt.

De la main gauche, elle présente un pair de bésicles au vieil homme.

Le jeune homme est richement vêtu de soie, satin et velours. Sur sa toque gansée, se dresse un ensemble de plume or et argent. La perle qu'il porte à l'oreille permet de dater le tableau, car c'est le roi **Henri III**, monarque esthète et extravagant, qui à lancé cette coutume.

Anonyme, portrait d'Henri III, huile sur bois, musée de châteaux de Versailles et de Trianon

Notre jeune premier a posé la main gauche sur l'épaule de la jeune femme et de l'autre, frôle avec délicatesse son sein droit. L'ombre portée sur la joue de sa compagne révèle la proximité du couple.

Troisième acteur, le vieil homme est vêtu d'une chausse et d'un pourpoint rouge vermillon couvert d'un long manteau aux amples manches, noir, ourlé et doublé de fourrure. Il porte une toque noire. Ce vêtement, c'est celui que portaient les riches marchands de Venise, à la fin du XVIème siècle.
Tout en regardant les bésicles qu'on lui présente, il fait des deux mains un geste évoquant le compte de l'argent…

L'auteur du tableau a construit l'intrigue par de subtils jeux de mains et de regards. Aux avances du riche vieillard, la jeune femme répond par un geste aussi élégant que dédaigneux : elle lui rend ses bésicles comme pour lui rappeler son âge avancé. De l'autre main, elle pince le petit doigt du jeune homme en signe d'approbation.

(4) Contexte d'apparition de cette œuvre
La réunion des amoureux et du vieillard ainsi que certains costumes sont inspirés de la comédie italienne, introduite progressivement en France à partir de 1571. Très populaire, la *Comedia dell'Arte,* née en Italie au milieu du XVIème s était interprétée par des troupes itinérantes de comédiens professionnels qui jouaient masqués des personnages stéréotypés et improvisaient sur des scénarios réglés d'avance.

Porbus, Commedia dell'arte a la cour de Charles IX, 1540-1584, Bayeux, Musée Baron Gérard

La Femme entre les deux âges pourrait bien représenter une scène comique avec les personnages de Pantalone, Horace et Lucia. Pantalone, vieux marchand vénitien est le prototype de l'amoureux âgé et berné.

Pantalone, vu par Maurice Sand, en 1860

Horace et Lucia forment un jeune couple d'amoureux inséparables, beaux et vêtus à la dernière mode, ingénieux pour tromper les vieillards.

Personnages de la comédie italienne, Musée de Beaux Arts de Béziers, Hôtel Fabregat

Ce thème a eu un succès énorme si on en juge par le grand nombre des œuvres que l'on peut y rattacher. Mais presque toutes semblent issues plutôt de la gravure de Perret datée de 1579 dans laquelle les personnages portent des costumes très archaïsants, sans doute flamands.

Comparaison: Gravure du Perret et Femme entre les Deux Ages, (habillée)

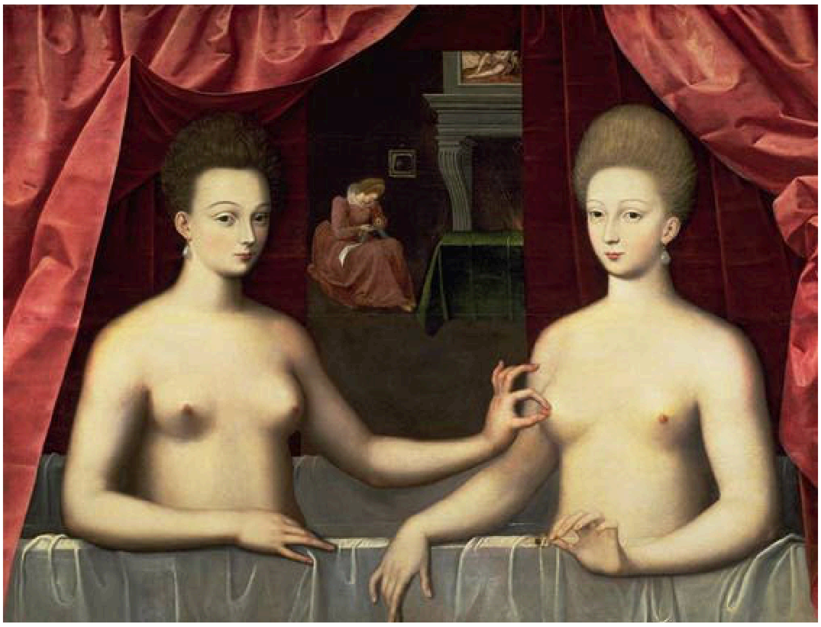
L'une de ces nombreuses versions est conservée a Rennes (inv. D.52.1.1, huile sur bois). L'attitude des personnages sont strictement les mêmes, hormis la geste du vieillard qui, comme dans la gravure s'enveloppe ici dans son manteau. D'autres peintures très proches sont connues au musée du Prado a Madrid, a la Scottish National Portrait Gallery d'Edingburg, a une collection privée parisienne, tandis que le Metropolitan Museum of Art a New York possède une version "abrégée" ou les deux amants figurent seuls.

La femme entre les deux âges, collection particulier, Paris

Ces copies sont très lies chronologiquement. Mais depuis la fin du XVIe siècle le thème n'a pas eu de suite, sans doute parce qu'il s'attachait trop étroitement a l'esthétique et a l'esprit de l'Ecole de Fontainebleau comme aux premiers rencontres avec la Commedia dell'arte.

(5) Attribution

Mentionné a partir de 1803 dans les collections du musée, cette œuvre aujourd'hui célèbre, a fait l'objet d'innombrables conjectures. Attribue d'abord à Holbein, puis à l'école Florentine, elle est en fait très caractéristique de l'école de Fontainebleau., qui nait suite a la reconstruction de 1528 du château, pendant laquelle plusieurs artistes italiennes deviennent actifs dans le cours royale influençant aussi les artistes français. Sous l'aimable prétexte de la mythologie, le nu féminin profane devient partout présent à Fontainebleau.



Aussi précises soient-elles, descriptions et explications historiques n'enlèvent pas le mystère du tableau…
A qui était-il destiné? Où était-il installé? Vu les ressemblances, faut-il voir dans le personnage du jeune premier un portrait du roi Henri III lui-même? Les interprétations, plus ou moins fantaisistes sont

multiples…A chacun d'imaginer par exemple quelle pourrait être la scène précédente! A chacun d'inventer un autre titre pour cette œuvre!
Car cette jeune femme continue, à travers les siècles, d'interpeller en silence chaque spectateur sur le choix qu'elle fait entre deux âges, entre deux hommes.

APPENDIX III: MAGIC ENGINE XML FILES (EXAMPLES)

A. MAGIC ENGINE ITEM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<param position_y="2.0"/>
<param position_z="3.0"/>
</GEOREF>
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<makerfile filename="../Data/pattern/picasso-hercules-a3.pat"/>
<size width="340" height="245"/>
<best_z value="1200"/>
<confidence value="0.80"/>
</marker>
<freeze_ref filename="REF_tableau_1.jpg" distance="800"/>
<sensor on="no"/>
<!-- this parameter is not used yet but could be used in the future -->
<model3D on="no"/>
<!-- this parameter is not used yet but could be used in the future -->
</TRACKING>
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<param text="La Baigneuse"/>
<!-- the title appears on the top of the main application window-->
</TITLE>
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<!-- image that appears when still far that lets the user know this
painting is commented-->
</FRAME>
</AWAY>
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<!-- definition of the main navigation widgets (that appear when the
visitor approaches a painting, corresponding to the main navigation themes)
and their representing 3d objects -->
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<!-- for each theme, eg description, a description of available media
follows, consisting of a widget consistently used for all paintings and the
name and location of the corresponding xml file-->
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```

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<onAction value="presentation" filename="pica_contexte_audio.xml"/>
</FRAME>
<FRAME>
<selection_index value="2"/>
<name value="Diaporama"/>
<size width="80" height="80"/>
<position_x value="160"/>
<position_y value="-150"/>
<position_z value="0"/>
<texture value1="slideshow.png"/>
<onAction value="presentation" filename="pica_contexte_pps.xml"/>
</FRAME>
<FRAME>
<selection_index value="3"/>
<name value="Retour"/>
<size width="80" height="80"/>
<position_x value="200"/>
<position_y value="120"/>
<position_z value="0"/>
<texture value1="new_arrow.jpg"/>
<onAction value="group" name="Theme"/>
</FRAME>
</GROUP>
<GROUP name="Artiste" type="none">
<FRAME>
```

```xml
<selection_index value="1"/>
<name value="Diaporama"/>
<size width="80" height="80"/>
<position_x value="160"/>
<position_y value="-150"/>
<position_z value="0"/>
<texture value1="slideshow.png"/>

<onAction value="presentation" filename="pica_bio_pps.xml"/>
</FRAME>
<FRAME>
<selection_index value="2"/>
<name value="Retour"/>
<size width="80" height="80"/>
<position_x value="200"/>
<position_y value="120"/>
<position_z value="0"/>
<texture value1="new_arrow.jpg"/>
<onAction value="group" name="Theme"/>
</FRAME>
</GROUP>
</MagicEngineItem>
```

B. MAGIC ENGINE PRESENTATIONS: VIDEO DEFINITION XML FILE

```xml
<?xml version="1.0"?>
<MagicEnginePresentation>
<MEDIASHOW name="Technique3">
<VIDEO>
<file value="pica_techni_video.avi"/>
</VIDEO>
</MEDIASHOW>
</MagicEnginePresentation>
```

C. MAGIC ENGINE PRESENTATIONS: 2D AND 3D SLIDESHOW AND TEXT DEFINITION XML FILE

```xml
<?xml version="1.0" ?>
<MagicEnginePresentation>
<MEDIASHOW name="Description3">
<PPS>
<file value="pica_descri_ppt.pps"/>
</PPS>
</MEDIASHOW>
</MagicEnginePresentation>
```

-

D. MAGIC ENGINE PRESENTATIONS: AUDIO DEFINITION XML FILE

```xml
<MagicEnginePresentation>
<MEDIASHOW name="Description2">
<DIAPO>
<size width="80" height="80"/>
<texture value="casque2.png"/>
<sound value="picasso_1.wav"/>
<position_x value="-160"/>
<position_y value="-120"/>
<position_z value="0"/>
```

```
</DIAPO>
</MEDIASHOW>
</MagicEnginePresentation>
```

APPENDIX IV: EXPERIMENTATIONS' PRESENTATION TO THE PARTICIPANTS

PRESENTATION DE L'ETUDE

Bonjour,
Vous participerez à une visite du musée des Beaux-Arts de Rennes dans le cadre de la conception et de l'évaluation d'un prototype de guide de musée multimédia. Votre participation se situe dans le cadre d'une étude scientifique liée à la conception de guides multimédia pour la visite culturelle, et plus particulièrement, en utilisant des technologies de Réalité Augmentée. Notre but n'est pas seulement de tester cette maquette mais aussi de l'améliorer et d'envisager d'autres fonctionnalités, avec votre aide.

Voici la manière dont l'expérimentation va se dérouler:
1) Dans un premier temps et pendant quelques minutes nous vous présenterons le dispositif et ses fonctionnalités.
2) Ensuite, vous pourrez effectuer une visite thématique, sur le thème du costume, dans 3 salles, dans lesquelles se trouvent les quatre œuvres (tableaux) commentées. Vous serez cependant libres de déambuler et d'observer d'autres œuvres qui peuvent vous intéresser.
Pendant votre visite vous serez équipé d'un dispositif numérique (dimensions :22 cm x 15cm , poids: 800g) .
Celui-ci vous permettra d'approfondir votre interaction avec les quatre tableaux présents dans ces trois pièces. On vous demandera également de porter un bandeau sur la tête qui sera équipé d'une caméra discrète, qui nous permettra de filmer vos sessions et votre interaction avec le dispositif.
Dans la mesure où le dispositif d'enregistrement est contraignant, nous vous demanderons lorsque vous utilisez le dispositif de réalité augmentée de le pointer vers les œuvres.
De plus, bien que vous puissiez vous promener librement au sein des trois salles, nous vous demandons de vous arrêter devant chaque tableau pour lequel des informations apparaîtront sur l'écran.

3) Cette visite sera suivie d'un entretien. Nous estimons que la visite suivie de l'entretien dureront au total à peu près une heure et demie. (+/- 10 min).

4) Enfin, un mois après la visite, vous devrez répondre à cinq questions par email.

5) Entre-temps, une séance de focus d'une heure environ vous sera également proposée début-novembre pour revenir sur votre expérience de visite. Cela sera le moment d'exprimer vos propres avis, opinions et idées par rapport au dispositif que vous avez utilisé et aussi de dialoguer et réagir avec d'autres participants.
Une rémunération est prévue par le biais de chèques kadeos utilisables dans de nombreuses enseignes dont la FNAC:
- 50 euros seront prévus pour la participation aux 4 phases
- 40 euros seront prévus pour la participation aux trois premières phases
Enfin, une fois sur place pour la visite, nous vous demanderons de signer le document de droit à l'image ainsi que de participation et rémunération reçue en conséquence.
Tous vos coordonnes ainsi que tout détail d'ordre personnel sera traité avec la plus grande discrétion. On aimerait cependant vous prévenir que les résultats de ces expérimentations sont susceptibles d'être divulgués dans des revues ou colloques scientifiques.

N'hésitez pas à nous contacter si vous avez d'autres questions concernant cette expérimentation.

Cordialement,
Areti Damala
Anne Bationo-Tillon

APPENDIX V: SOME INTERVIEW TRANSCRIPTS

INTERVIEW, Florence, 1st year of studies, Social Sciences Student

Interviewer: Would you mind tell me how old are you and which year of studies you are attending at the university?

Student: I am a 1st year student and I am 19 years old.

Interviewer: Let me write that down, first year …

Interviewer: So, how was it?

Student: Eh…good…

Interviewer: Was it easy or hard to locate the paintings?

Student: No, it was easy.

Interviewer: OK then… Do you think that the structure of the content was clear enough? I mean the different thematic axes present for each painting?

Student: Yeah…but there were too many things present at the same time and it is not easy to retain all at once… but otherwise the content was rich, there were many things.

Interviewer: Was there anything that caused particular problems or a kind of presentation that was not easy to follow?

Student: No. There was nothing that perturbed me.

Interviewer: Do you think that it (the guide) helped you to approach or comprehend the subject depicted or did it rather distract you from contemplating the painting or both at the same time?

Student: (I would say) it rather provided me with...helped me better understand the painting. I found it very interesting to see how the painting was made, all the "behind", like the artist's point of view…

Interviewer: I see…

Student: But then there are things that ….hem…for example in the life of the artist, that are interesting, but maybe not necessary.

Interviewer: Uh?

Student: I don't know if I expressed myself clearly…

Interviewer: It is very interesting for us to have all points of view and receive positive and negative comments for the guide…so as to see what goes fine and what maybe not so fine…

Student: Eh, no, it is true that using the guide was quite playful, this is not bad, and then it allows as having interpretation material on hand.

Interviewer: Was there any content that you enjoyed more than others?

Student: Ah…Yes of course. The "context" and the "artist" themes, and then the "description" as well, because as we have the painting right in front of us, we can see…

Interviewer: Speaking generally, would you say that you like visiting museums often, regularly, a lot?

Student: I like a lot visiting, but I do not visit regularly… when I am in places where I have not been before, I visit a lot but I am not crazy about museums as well.

Interviewer: When you visit, do you usually prefer being alone or you prefer going with friends?

Student: More with other people, so that we can as well discuss, because it's funny to see the impression a painting can make to different people. But I like visiting alone as well.

Interviewer: And once you are in a museum, if an object appeals to you, how do you do to obtain more information? Do you use interpretation material if there is any available?

Student: Yes, yes…I try to…First, I observe a lot the painting with attention, then I read the information next to it (the etiquettes), if there is interpretation material it is even better.

Interviewer: Is there any interpretation material that you prefer among others? Like text, audio, guided visits?

Student: Guided visits no. I prefer that (alternative) interpretation material is proposed to me, so that I can choose…I find that a guided visit often is a bit…well then of course it depends on the place as well…but the guided visit is a bit too guided…the personal choice in a museum is important, like being able to pass from one painting to another if we like, being able to choose, you see?

Interviewer: I see…

Student: Then I am also thinking about audio guides, but…it is the same, we don't find them everywhere.

Interviewer: It's true…

Interviewer: So, if a guide like this one was available in the museum, of course without all this additional equipment you had to wear, do you think you would give it a try?

Student: Yes, I think. Because we can choose the information we want, and then we choose as well the order. Personally I think I would use it.

Interviewer: So you told me before that you think the structure was clear. Were the types of media available under each theme comprehensible?

Student: Yes, yes it was quite clear, except maybe for the two black squares…

Interviewer: Yes of course, it was the pictogram we chose for the slideshows.

……….

INTERVIEW, Simon, 3rd[t] year of studies, Social Sciences Student

Interviewer: Simon, would you mind telling me how old are you?

Student: I am 20 years old

Interviewer: Would you say you visit museums rarely, often or frequently?

Student: I am putting myself on it more and more

Interviewer: I see…

Student: It is not a habit I have since I was little, but by growing up, I started finding it more and more interesting, and now, whenever I find the chance, yes, I go…

Interviewer: How is your relation regarding New Technologies, like Internet, mobile phones or related gadgets?

Student: I am hopeless (laughs)…But I start to get myself using to the idea, as we are required more and more to know a minimum…I was obliged last year to buy a PC, for example, which was something I had never considered before, so when I bought one, by using it…and as I like a lot music… you know there is plenty of software that is very good for music, for guitar in particularly, things like that, so by trying and using all that stuff, we start to get used.

Interviewer: I see.

Student: But that does not mean that this is my favourite hobby.

Interviewer: So you don't really use them by obligation, but more for fun and it is this way you started learning things on computers.

Student: Yes, exactly. And then I like having things in order; so instead of having files here and there…I bought myself an external hard disk. But the more I use them, the more I like to have performant material that works well….But I still get lost, in comparison with others… (laughs)
Interviewer: Let me get back in museum visiting now. When you visit do you usually prefer visit alone or accompanied?

Student: Ah! It depends with whom…Because me, my look on the works, is something very personal. So for example, a person that does not have the same look , it is difficult, so in this case, we might go together, but each one will be progressing in his own pace…Or we might share the liking for the same works, but this can be very different from person to person. But then it really depends on the person. For example I recently did a visit with a friend (female) that explained me many things on the painting. She is studying history of art, so she had lot of knowledge that she could give, and that is a very interesting example of a visit made by two. On the contrary making a visit with somebody that does not have the same likings as ours… in this case splitting up and making individually our own visit could be better.

Interviewer: So, let's say that we are in the museum, alone or accompanied, do you have a particular method of approaching, looking or understanding the object that interests you? Do you like just watching or do you fancy finding information, resources available? Like text provided by the museum or audio guides?

Student: There are three things in a painting. First of all there are the senses (meaning the feeling) what the painting transmits us. For example, the faces, the emotions, or everything else that belongs to this category. Then there is the beauty. Eh…..The beauty both ways. The beauty with its philosophical sense or what is represented. Is it a scene of war or another historic event? And then the beauty in terms of aesthetics... Do I like it or not? And the third point is the technique.

Interviewer: So you are also interested by the technique.

Student: Yes, and very much indeed. Very much because it happens to me to see painting so as to understand how other artists do, that gives us new ideas and invites us to compare and to see.. Whether it is a sculptor or a painter…all this. Like for example in the painting we saw a while ago, the fact that the painting was reframed and both frames were preserved…These are small aspects and things that I like discovering in paintings.

Interviewer: So, here comes a hypothetical question.

Student: Hum hum …

Interviewer: Let's say that a guide like that is available and it does not contain only 4 paintings but maybe 10 or 12 or 14. Do you finally think that this is something that could help you understand the context of the painting a bit better? Or do you think on the contrary that it would rather distract you? It's the one or the other? Or, maybe, both at the same time?

Student: Well, it depends. I think that the guide is very interesting, it provides us with amazing things, the comprehension and the knowledge, but you have to be careful in watching also the painting on its own and take the time to see the things. I think it is also interesting to have the time to see the painting on it's own where we analyse what we see, and then we can have a guide that explains us the technique, the context and the artist, and then have some more time, to re-see the painting on it's own and compare with the feelings it provoked us at first. It's like that we are constructing ourselves a personal feeling or apprehension of the painting. Yes, yes, I think it is interesting. Personally I like it a lot.

Interviewer: What would be the advantages or the disadvantages regarding other ways of media available in the museum, more conventional in nature? Text, museum provided texts or audio guides?

Student: What I liked is that we can replay the information we like. Well then of course, one has to be careful so that the guide does not take the place of the work. At the beginning, I felt a bit this. I had this thing in my hands, and my look was focused on it. Despite the fact that I had the painting just in front of me, at the beginning it was the guide I was looking. But then, I started taking my time. When there was only the audio I was watching… Then what else I could say for the prototype I used, hem…, there were images for example, where there were no references. So there we don't know what we see, who did it and why, all these…There are certain ones for which we don't know. Then it was also the fact that holding the guide just in front of the eyes was a bit tiring…and it also interfered with watching the painting …but I guess that this configuration was only for the trial.

Interviewer: What I find interesting, is that if a kind of mistake slips in it becomes apparent, which is not the case with audio guides or text (one should be a specialist) but many of you made this remark, a thing that shows that you were careful to what you were watching and seeing.

Student: It's better to adopt a critical view of things but still I find the comparison images were not referenced either their scale or dimensions.

Interviewer: … Did you observe that there was a bar with the title on top of each painting presented?

Student: Yes, I did.

Interviewer: We feared that it might not be visible enough …. We would really like to discuss other aspects like these with you in the workshop. But otherwise do you think the themes were comprehensible?

Student: Yes, I think that analysis should be at the end, at my opinion. So I did this only at the end. I did not understand if there is an order, or we could do the things differently.

Student: Oh, and in Picasso there was a text and an audio. The text was very small and I did not have my glasses, I tried to read it and then I passed on the audio, and then I realized that it is the same thing…

Interviewer: Yes, you are right. But what I would like to ask you in this case, is do you think that the same kind of information should be delivered using different media? Would that help?

Student: Of course, it can be very interesting, then it depends for which public, that is also what I asked Pascal (note: a member of the research team) before starting the experimentation, for which public? So as to know how I am going to "judge" it…If it could touch a maximum of the public that would be great. It is nice to have audio, text, eh, all these… Then if they are the same, they have to be grouped together. I would like being able to pause in the audio and think or go back and rehear something if I want.

Student: Another technical thing as well is that the Picasso painting was small so when I approached, the images of the themes moved, some of them were outside the screen.

……

INTERVIEW, Marie-Laure, 1st year of studies, Fine Arts Student

Interviewer: I am going to ask you some questions now, quite quickly as it seems that we do not have much time.

Student: I am ready.

Interviewer: So you told me you are at the 2nd year of your studies in the School of Fine Arts and how old are you?

Student: I am 20 years old.

Interviewer: Would you say you visit museum rarely, regularly or often?

Student: I would say very regularly.

Interviewer: And usually when you are in a gallery or a museum you prefer being alone or with friends?

Student: Either with friends with the same background so as to discuss…but… I like a lot visiting alone as well. Generally, most of the times, I visit museums on my own.

Interviewer: And what is your preferred interpretation material once in a museum? How do you usually proceed?

Student: Already what really irritates me in contemporary art is that there is not an enormous offer in terms of interpretation, so that annoys me a little bit… I like a lot having text, actually. Whatever is audio guide, I do not like a lot… because I find that my attention goes away very soon…except if there is a (human) guide

Interviewer: Now, a somewhat arduous question as we came upon some problems during your visit… (laughs)

Student: (laughs)

Interviewer: Given the fact that you visit museums, and that you usually prefer using text, the fact of having a multimedia guide your hands, what did it give? Did it distract you? How did things pass? Not necessarily at the beginning, because in the beginning we need some time to adjust ourselves…

Student: Yes, we need some time to adjust…

Interviewer: But when you got at ease…

Student: Well already, I found very interesting the fact of having the image and the text, and that the text is active, I liked it more than the audio.

Interviewer: And whatever was image that appeared alongside with audio? How was the combination?

Student: Eh, maybe a bit too…eh I prefer taking my time by myself to read a text…because when we have only the audio, we absorb some things but other things are put aside, while with the text we take our time. But the combination of appearing images and text was a very good one.

Interviewer: In terms of structure of the content, were things clear enough?

Student: Yes, everything was clear

Interviewer: Trying to make an abstraction, you think that using the guide was easy or too complicated?

Student: (laughs) I would say that it's me who didn't understand everything from the beginning…

Interviewer: No…

Student: I didn't! I am not very gifted in terms of Information Technologies (laughs).

Student: Well, I think there is an adaptation time, but once we understand how it works, it's the same, but I would say that it's the same in the case of an audio guide as well, we don't catch directly which button we have to press at the beginning

Interviewer: Right…I see… ere I am tempted to ask you something because you said that you use text quite a lot but you have also used audio guides. So here is the question…

Student: Yes…

Interviewer: Let's say that you are in the museum with the interpretation medium that you have already chosen, either it is text or audio…and you see a painting and you want to have more information, how do you usually proceed?

Student: If we have the audio guide or what?

Interviewer: Actually, what I want to ask you is how you identify the piece of information that will help you… I mean you walk with a printed guide…

Student: A, yes. Actually the first thing that I do is to take the museum brochures and I prefer in general, I take a look quickly so as to have a personal opinion on what I see before I read but then I take the time to read and I go back to see elements that interest me or and that I might have not seen…but the text is also "heavy" some times. You see, recently I was at the exhibition at the …(centre of contemporary art, in Rennes) this week, so they gave as text that was without images, without anything. We are much less attracted to read in comparison with the multimedia guide, so this way it is much easier to read.

Interviewer: And in terms of navigation in the information in this case and identification of information, with the combination of image and text was it more or less difficult to go through the content?

Student: It was much more interesting than having only text

Interviewer: OK. That's all very interesting and I would like as very much to discuss some of these topics in the workshops that will follow

Student: Is the system proposed very immature in terms of technology?

Interviewer: Not as much as that.
(…A small discussion about AR follows)

APPENDIX VI: THE SURVEY

A. THE CONTENT OF THE SURVEY (TRANSLATED FROM FRENCH TO ENGLISH)

France Telecom Research and Development – Museum of Fine Arts, Rennes
Mobile Multimedia Guide Survey

1. Welcome and introductory note

Hello everybody!

You are invited to answer in this online survey concerning your experience using the multimedia guide of the Museum of Fine Arts in Rennes. This questionnaire contains questions regarding several aspects of your visit.

The estimated duration for the completion of the questionnaire is about 10 minutes.

Your questions will be coded and treated anonymously. The publication of the results will not reveal in any case personal data. It will also be impossible for any other person not related with the experimentations to have access to your personal data.

For any question regarding the survey and the questions you can always contact me at my email address, or at my mobile or fixed phone number.

Thank you once again for your participation, your remarks, your enthusiasm and your help. You can now proceed in answering the questions by clicking on the "next" button below.

See you very soon!
Areti DAMALA

2. Some general questions:

1. How old are you? ______________________________

2. Please, write down your name and surname: ______________________________

3. Your email address is: ______________________________

4. In general, you visit museums:

   ○ Very often (4 times per year or more)

   ○ Regularly (in between 2 and 3 times per year)

   ○ Rarely (1 time per year or so)

   ○ Never

5. If you have already visited museum, do you prefer visit (please, choose only one answer):

   ○ Alone

   ○ With friends or family

   ○ In group

6. Once in the museum, do you use interpretation material?

○ Yes

○ No

7. If yes, do you usually use (check one or more answers)

○ audio guide

○ guided visits

○ printed books

○ text available on site

○ the museum's web site

○ multimedia kiosks

○ other

8. Had you already visited the Museum of Fine Arts in Rennes?

○ Yes

○ No

9. If yes, your last visit was ……. Ago

10. Generally speaking, you use a PC:

○ Very often (everyday)

○ Regularly (several times per week)

○ Rarely (several times per month)

○ Never

11. You own a mobile phone form the age of ______________

3. Questions regarding the use of the guide

1. Identifying the commented works in the museum was easy

○ Mostly Agree

○ Somewhat Agree

○ Somewhat Disagree

○ Mostly Disagree

2. Navigating in the content was easy

○ Mostly Agree

○ Somewhat Agree

○ Somewhat Disagree

○ Mostly Disagree

3. Using the guide was easy

○ Mostly Agree

○ Somewhat Agree

○ Somewhat Disagree

○ Mostly Disagree

4. The display of the virtual objects alongside with the real ones, facilitated my access in the content

○ Mostly Agree

○ Somewhat Agree

○ Somewhat Disagree

○ Mostly Disagree

5. The tutorial at the beginning provided useful explications about using the guide

○ Mostly Agree

○ Somewhat Agree

○ Somewhat Disagree

○ Mostly Disagree

6. Is there anything that you would like the guide to do?
……………………………………………………………………………………………
……………………………………………………………………………………………

7. Is there anything that you would like the guide not to do?
……………………………………………………………………………………………
…………………………………………………………………………….....................

4. Questions related with the content of the guide

1. The thematic axes (themes) available for every painting were comprehensible:

○ Mostly Agree

○ Somewhat Agree

○ Somewhat Disagree

○ Mostly Disagree

2. The quality of the audio comments corresponds to what I would expect from a multimedia guide.

○ Mostly Agree

○ Somewhat Agree

○ Somewhat Disagree

○ Mostly Disagree

3. The quality of the available text corresponds to what I would expect from a multimedia guide.

○ Mostly Agree

○ Somewhat Agree

○ Somewhat Disagree

○ Mostly Disagree

4. The fonts were neither too small nor too large.

○ Mostly Agree

○ Somewhat Agree

○ Somewhat Disagree

○ Mostly Disagree

5. The audio comments, in terms of duration, were:

○ not long enough

○ satisfactory

○ much too long

○ not interested in having audio on such a guide

6. The texts, in terms of length, were

○ not long enough

○ satisfactory

○ much too long

○ not interested in having text on such a guide

7. The quality of the multimedia presentations (the presentations that combined audio and images) was satisfactory

○ Mostly Agree

○ Somewhat Agree

○ Somewhat Disagree

○ Mostly Disagree

8. The duration of the multimedia presentations (the presentations that combined audio and images) was:

○ not long enough

○ satisfactory

○ much too long

9. The additional comparative images included in the guide:

○ interfered with my appropriation of the painting

○ helped me better approach the contemplated painting

○ other (please, precise)

…………………………………………………………………………
…………………………………………………………………………

10. Which of these prepositions better describe the way that you used the guide :
(choose more than one answer if necessary):

○ I read the texts

○ I listened to the audio

○ I watched the provided images

○ I watched a video

○ I watched the multimedia presentations

5. Questions related to the object versus the guide

1. I find that using the guide distracted my attention from the original work of art.

○ Mostly Agree

○ Somewhat Agree

○ Somewhat Disagree

○ Mostly Disagree

2. Using the guide was playful

○ Mostly Agree

○ Somewhat Agree

○ Somewhat Disagree

○ Mostly Disagree

3. Using the guide helped me better understand and appreciate the paintings.

○ Mostly Agree

○ Somewhat Agree

○ Somewhat Disagree

○ Mostly Disagree

4. I learned more that what I would have learned had I not used the guide.

○ Mostly Agree

○ Somewhat Agree

○ Somewhat Disagree

○ Mostly Disagree

5. The visit experience was better than the one I'd have had I not used the guide.

○ Mostly Agree

○ Somewhat Agree

○ Somewhat Disagree

○ Mostly Disagree

6. What did you most appreciate?
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

7. What did you find more difficult?
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

6. Questions on the paintings

1. Do you remember how many paintings were commented?
……………………………………………………………………………………….

2. Do you remember one or more of the artists whose work was commented?
……………………………………………………………………………………….

3. Do you remember one or more of the subjects depicted?
…………………………………………………………………………………………
…………………………………………………………………………………………

4. Before the visit had you already heard the term « Virtual Reality» ?

○ yes
○ no
○ maybe

5. Before the visit had you already heard the term «Augmented Reality »?

○ yes
○ no
○ maybe

6. If yes, do you think you could give a definition for the term Augmented Reality?
…………………………………………………………………………………………
…………………………………………………………………………………………

7. I would use such a guide if it was available in the museum
○ yes
○ no

○ maybe (in this case, please precise)
………………………………...
………………………………………………………………………………………

8. “Having a guide that would include all of the commented works of the Museum of Fine Arts in Rennes is impossible” if this was the case, I would expect to find at least…………….commented

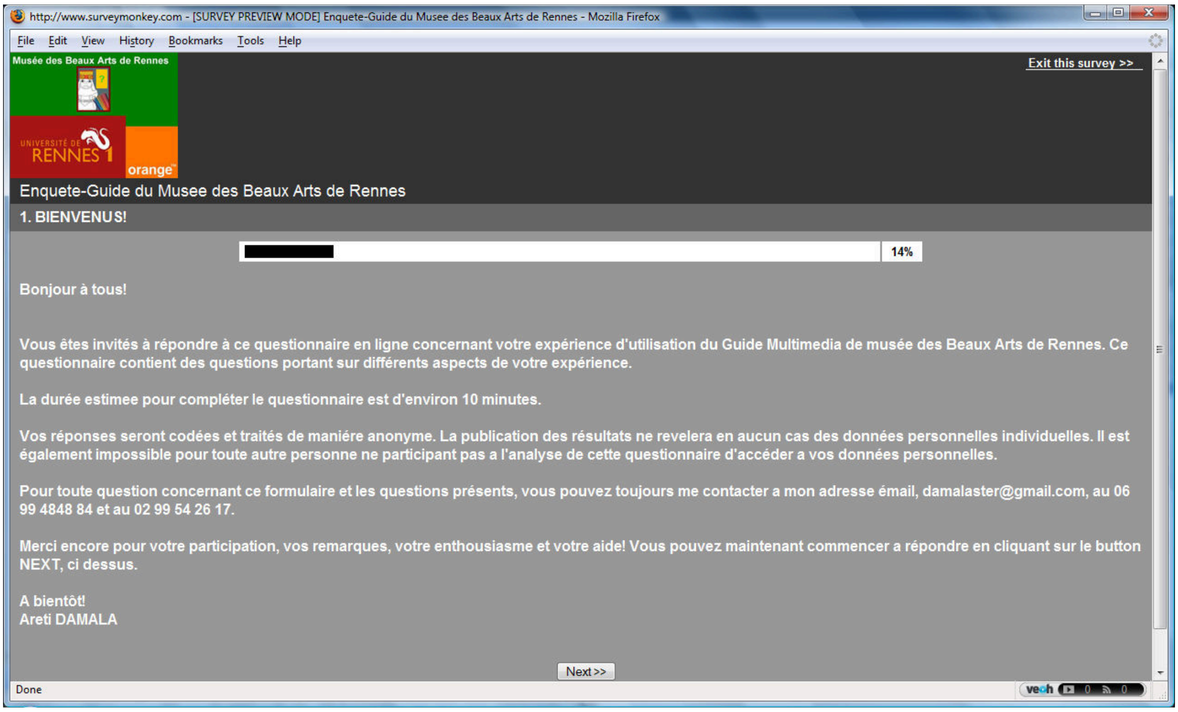
10. If you had any expectations regarding the guide, before your visit, thank you for writing down a comment.
………………………………………………………………………………………
………………………………………………………………………………………

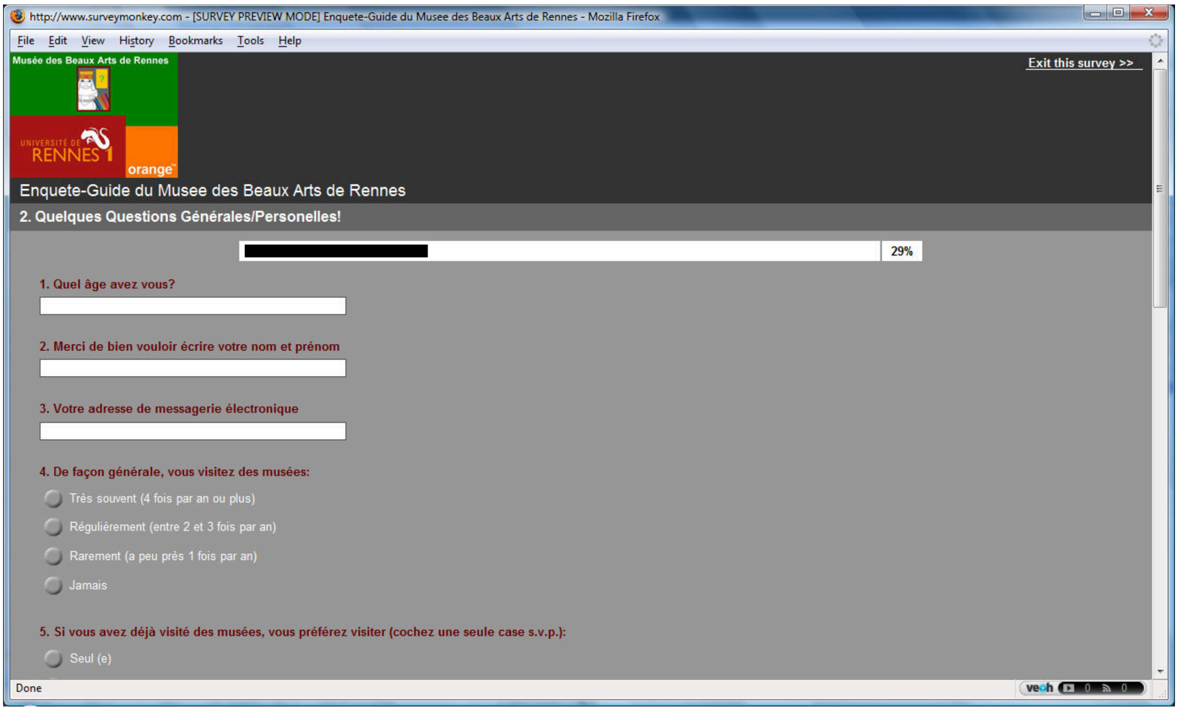
11. Following your visit in the Museum of Fine Arts, did you try to find any information regarding the paintings or the artists ?
……………………………………………………………………………………….

12. I would also like to note that…
…………………………………………………………………………………………
…………………………………………………………………………………………

Thank you once again for your participation!

B. THE WEB VERSION OF THE SURVEY





C. A HANDWRITTEN FILLED-IN SURVEY

1. BIENVENUS!

Bonjour à tous!

Vous êtes invités à répondre à ce questionnaire en ligne concernant votre expérience d'utilisation du Guide Multimedia de musée des Beaux Arts de Rennes. Ce questionnaire contient des questions portant sur différents aspects de votre expérience.

La durée estimee pour compléter le questionnaire est d'environ 10 minutes.

Vos réponses seront codées et traités de manière anonyme. La publication des résultats ne revelera en aucun cas des données personnelles individuelles. Il est également impossible pour toute autre personne ne participant pas a l'analyse de cette questionnaire d'accéder a vos données personnelles.

Pour toute question concernant ce formulaire et les questions présents, vous pouvez toujours me contacter a mon adresse émail, damalaster@gmail.com, au 06 99 4848 84 et au 02 99 54 26 17.

Merci encore pour votre participation, vos remarques, votre enthousiasme et votre aide! Vous pouvez maintenant commencer a répondre en cliquant sur le button NEXT, ci dessus.

A bientôt!
Areti DAMALA

2. Quelques Questions Générales/Personelles!

1. Quel âge avez vous?

20 ans

2. Merci de bien vouloir écrire votre nom et prénom

[illegible]

3. Votre adresse de messagerie électronique

[illegible]

4. De façon générale, vous visitez des musées:

- ◯ Très souvent (4 fois par an ou plus)
- ◯ Régulièrement (entre 2 et 3 fois par an)
- ◯ Rarement (a peu près 1 fois par an)
- ◯ Jamais

5. Si vous avez déjà visité des musées, vous préférez visiter (cochez une seule case s.v.p.):

- ◯ Seul (e)
- ◯ Avec des ami(e)s ou en famille
- ◯ En groupe

6. Une fois dans le musée,d'habitude, utilisez-vous des supports éducatifs:

- ◯ Oui
- ◯ Non

7. Si oui, est-ce que vous utilisez (cocher une ou plusieurs cases)

- ☐ des audio guides
- ☐ des visites guidées
- ☐ des guides sous forme de livre
- ☒ des fiches éducatives (si disponibles sur place)
- ☐ le site web du musée
- ☐ des bornes multimédias

Autre

8. Aviez-vous déjà visité le musée des Beaux Arts de Rennes?

- ◯ oui
- ◯ non

9. Si oui, votre dernière visite a eu lieu, il y a.......

10. De façon générale vous utilisez un ordinateur:

- ◯ Très souvent (tous les jours)
- ◯ Régulièrement (plusieurs fois par semaine)
- ◯ Rarement (plusieurs fois par mois)
- ◯ Jamais

11. Vous disposez d'un télèphone mobile depuis l'âge de...

3. Questions par rapport à l'utilisation du guide

1. La localisation des œuvres commentées dans les salles était facile.

- ◯ Tout à fait d'accord
- ◯ Plutôt d'accord
- ◯ Plutôt pas d'accord
- ◯ Pas du tout d'accord

2. Parcourir le contenu était facile.

- ◯ Tout à fait d'accord
- ◯ Plutôt d'accord
- ◯ Plutôt pas d'accord
- ◯ Pas du tout d'accord

3. L'utilisation du guide était facile.

- ◯ Tout à fait d'accord
- ◯ Plutôt d'accord
- ◯ Plutôt pas d'accord
- ◯ Pas du tout d'accord

4. L'affichage des objets virtuels à coté des objets réels a facilité mon accès au contenu.

- ◯ Tout à fait d'accord
- ◯ Plutôt d'accord
- ◯ Plutôt pas d'accord
- ◯ Pas du tout d'accord

5. Les explications fournies au départ par le dispositif étaient utiles.

- ◯ Tout à fait d'accord
- ◯ Plutôt d'accord
- ◯ Plutôt pas d'accord
- ◯ Pas du tout d'accord

6. Y a-t-il quelque chose que vous aimeriez que le dispositif fasse ?

7. Y a-t-il quelque chose que vous aimeriez que le dispositif ne fasse pas ?

4. Questions par rapport au contenu du guide

1. Les thématiques disponibles sur chaque œuvre étaient compréhensibles.

- Tout à fait d'accord
- Plutôt d'accord
- Plutôt pas d'accord
- Pas du tout d'accord

2. La qualité des commentaires audio correspond à ce que j'attends d'un guide multimédia.

- Tout à fait d'accord
- Plutôt d'accord
- Plutôt pas d'accord
- Pas du tout d'accord

3. La qualité du texte disponible correspond à ce que j'attends d'un guide multimédia.

- Tout à fait d'accord
- Plutôt d'accord
- Plutôt pas d'accord
- Pas du tout d'accord

4. La taille des caractères était ni trop petite ni trop grande.

- Tout à fait d'accord
- Plutôt d'accord
- Plutôt pas d'accord
- Pas du tout d'accord

5. La durée des commentaires audio est:

- pas assez longue
- satisfaisante
- beaucoup trop longue
- pas intéressé(e) d' avoir de l'audio sur un tel dispositif

6. Les textes (longueur) étaient:

- pas assez long
- satisfaisant
- beaucoup trop long
- pas intéressé(e) d' avoir du texte sur un tel dispositif

7. La qualité des présentations multimédia (les présentations qui combinaient son et images) était satisfaisante.

- Tout à fait d'accord
- Plutôt d'accord
- Plutôt pas d'accord
- Pas du tout d'accord

8. La durée des présentations multimédia (les présentations qui combinaient son et images) était:

- pas assez longue
- satisfaisante
- beaucoup trop longue

9. Les images comparatives des œuvres dans le guide:

- ont interféré avec mon appropriation de l'œuvre (de façon négatif)
- m'ont aidé à mieux approcher l'œuvre contemplée
- autre

10. Les quelles de ces propositions décrit le mieux la façon dont vous avez utilisé le guide (cochez plusieurs cases, si nécessaire):

- J'ai lu les textes
- J'ai écouté l'audio
- J'ai regardé les images fournies
- J'ai regardé une vidéo
- J'ai visionné les présentations multimédia

5. Questions par rapport à l'œuvre et le dispositif

1. Je trouve que l'utilisation du guide a détourné mon attention de l'œuvre originale.

- Tout à fait d'accord
- Plutôt d'accord
- Plutôt pas d'accord
- Pas du tout d'accord

2. Utiliser le guide était ludique.

- Tout à fait d'accord
- Plutôt d'accord
- Plutôt pas d'accord
- Pas du tout d'accord

3. L'utilisation du guide m'a aidé à mieux comprendre et apprécier les œuvres.

- Tout à fait d'accord
- Plutôt d'accord
- Plutôt pas d'accord
- Pas du tout d'accord

4. J'ai appris plus que ce que j'aurais appris sans utiliser le guide.

- Tout à fait d'accord
- Plutôt d'accord
- Plutôt pas d'accord
- Pas du tout d'accord

5. L'expérience de la visite était mieux que ce que j'aurais si je n'avais pas utilisé le guide.

- Tout à fait d'accord
- Plutôt d'accord
- Plutôt pas d'accord
- Pas du tout d'accord

6. Qu'est ce que vous avez le plus apprécié?

- le power point à la fin

7. Qu'est ce que vous avez trouvé difficile?

6. Questions sur les œuvres

1. Vous rappelez-vous combien d'œuvres ont été commentées?

NON

2. Vous rappelez-vous un ou plusieurs noms des artistes dont l'œuvre a été commentée?

Picasso

3. Vous rappelez-vous un ou plusieurs sujets représentés?

- 450 ans

4. Avant la visite, aviez-vous déjà entendu parler de la Réalité Virtuelle?

- oui
- non
- peut-être

5. Avant la visite, aviez-vous déjà entendu parler de la Réalité Augmentée?

- oui
- non
- peut-être

6. Si oui, pensez-vous pouvoir donner une définition du terme Réalité Augmentée? Lequel???

7. J'utiliserais un tel guide s'il était disponible au musée:

- oui
- non
- peut-être (dans ce cas, merci de préciser...)

peut-être

8. Avoir un guide qui comporterait toutes les œuvres exposées au Musée des Beaux Arts de Rennes est impossible, si c'était le cas, j'attendrais au moins [NOMBRE DES OEUVRES] œuvres commentées.

entre 40 et 50

9. Si vous aviez quelques attentes par rapport au guide avant ta visite, merci d'écrire votre commentaire...

10. Suite à votre visite au Musée des Beaux Arts, avez-vous essayé de trouver des informations sur les œuvres ou les artistes?

Non

11. Enfin, y- a- t-il un autre commentaire que vous aimeriez partager avec l'équipe de conception et de l réalisation?

7. Remerciements!

Merci encore d'avoir participé a cette enquette!

1. Est ce que vous souhaiteriez avoir des nouvelles par rapport aux resultats de ces experimentations?

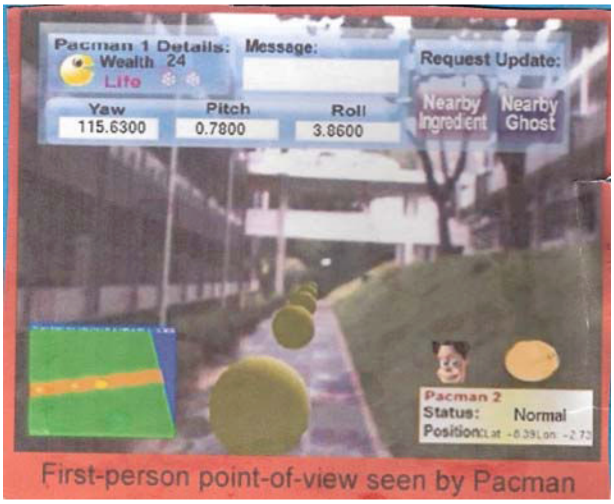
- ○ Oui (si oui, merci de bien vouloir nous laisser également votre adresse postale!)
- ○ Non

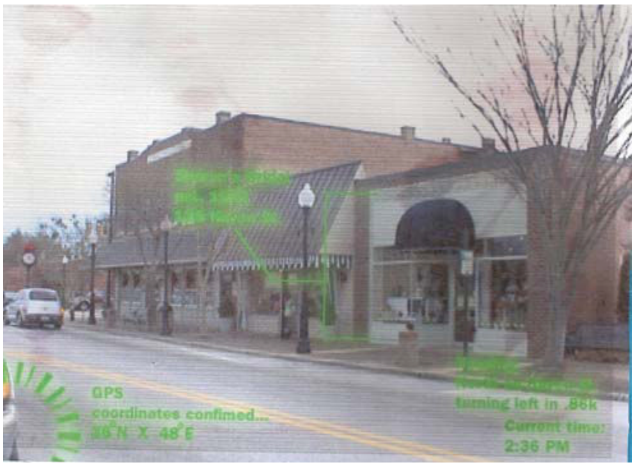
Adresse postale

APPENDIX VII: THE AR POSTERS PRESENTED DURING THE FOCUS GROUPS

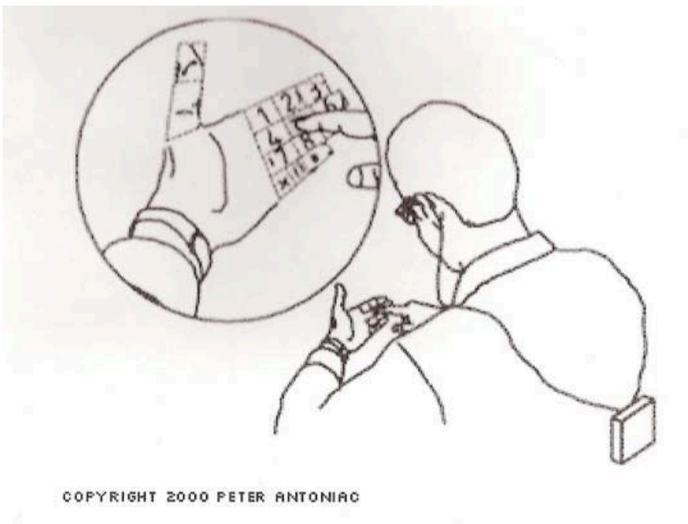
A. THE FIRST POSTER (CULTURAL HERITAGE RELATED APPLICATIONS)

B. THE SECOND POSTER (URBAN ENVIRONMENT AR APPLICATIONS)



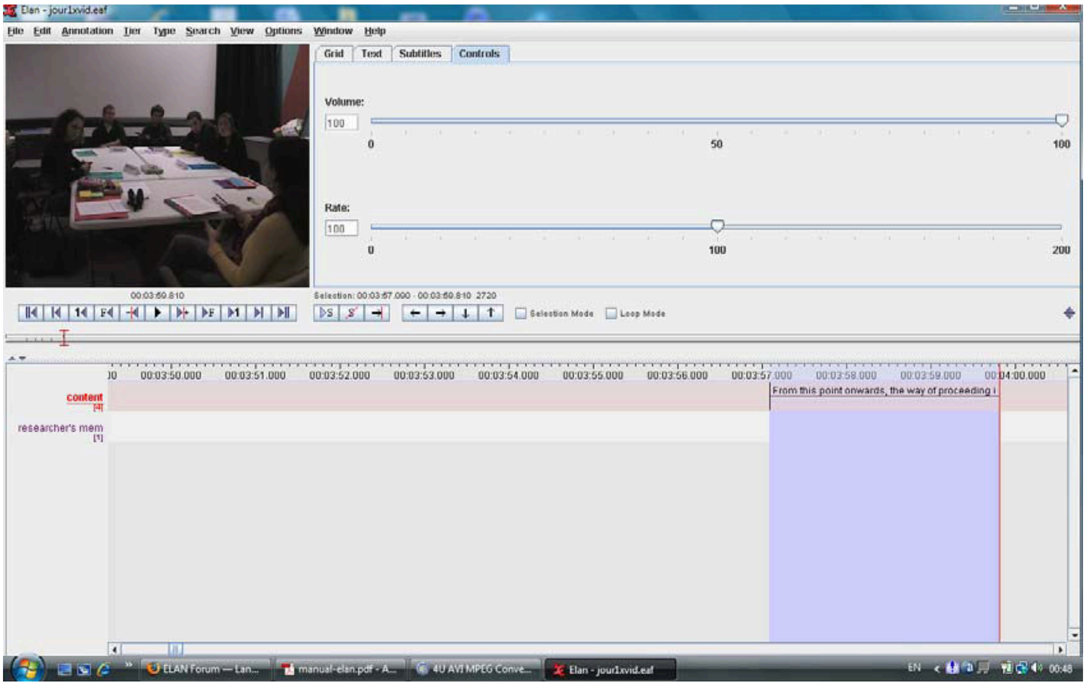


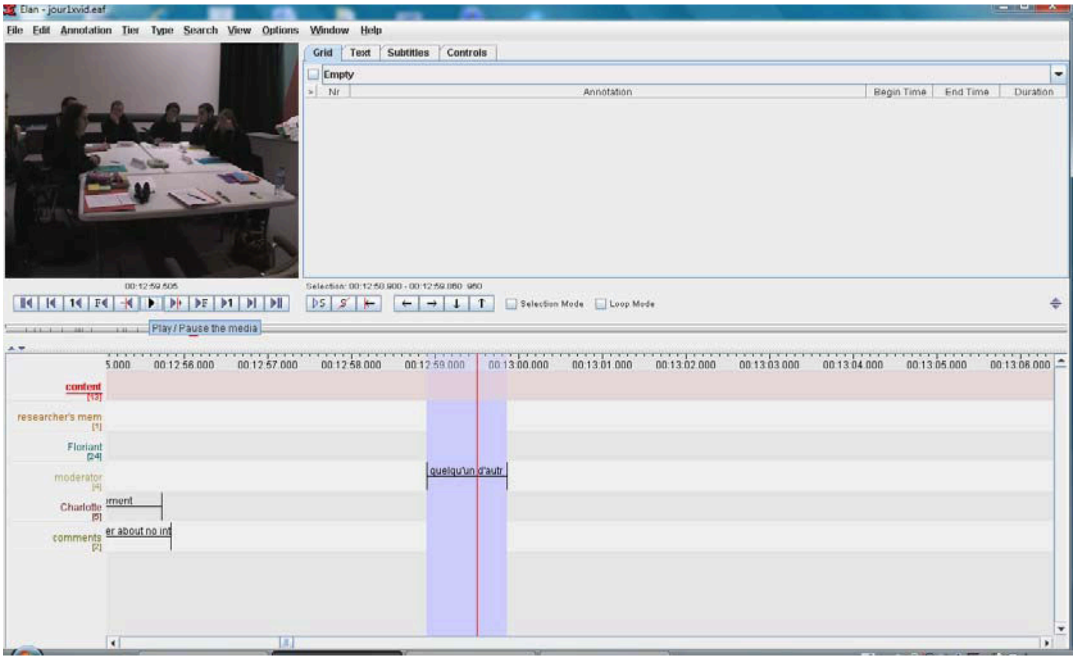
C. THE THIRD POSTER (INDUSTRIAL AR APPLICATIONS)



APPENDIX VIII: TRANSCRIBING THE FOCUS GROUP SESSIONS

A. SNAPSHOTS OF THE ELAN SOFTWARE USED FOR THE FOCUS GROUP TRANSCRIPTIONS





B. FOCUS GROUP TRANSCRIPT EXAMPLE

(Occasional museum goers, 2nd focus group)

…………….

moderator museums and museum visiting
TC 00:32:57.900 - 00:32:59.160

moderator (topic introduced : the reasons for which the participating students visit or do not visit museums quite often)
TC 00:33:19.830 - 00:33:22.880

Elise the price !
TC 00:33:30.670 - 00:33:31.870

moderator (most students laugh at this point)
TC 00:33:31.840 - 00:33:32.480

Johan you also have to take the time
TC 00:33:37.870 - 00:33:39.490

Johan it's much easier to find other things to do
TC 00:33:42.570 - 00:33:45.030

……………..

Elise you have to give yourself the time to do this
TC 00:33:57.940 - 00:33:59.590

Marine it can take long
TC 00:34:05.610 - 00:34:07.650

Simon for me too it is also to find the time but it is also the length (of the visit)
TC 00:34:16.770 - 00:34:18.980

Simon I don't know if (it is because) I am lazy
TC 00:34:19.330 - 00:34:21.040

Simon but it is also the price
TC 00:34:21.720 - 00:34:22.970

moderator what is your image of the museum as a leisure environment ?
TC 00:34:38.890 - 00:34:41.750

Elise it is not because you get older that suddenly
TC 00:35:36.140 - 00:35:38.650

Elise you get the habit to go and see a museum
TC 00:35:39.280 - 00:35:41.660

Elise people might feel like going to a museum
TC 00:35:42.360 - 00:35:44.880

Elise but I think that you have to be initiated
TC 00:35:46.680 - 00:35:49.030

Elise by parents, friends, the school, by somebody
TC 00:35:49.510 - 00:35:51.780

Elise it is not (always) a spontaneous initiative
TC 00:35:57.910 - 00:35:59.420

Marine we often hesitate to go because we are not necessarily informed
TC 00:35:59.390 - 00:36:02.090

Marine and in front of a painting we feel a bit «limited»…
TC 00:36:02.820 - 00:36:07.270

moderator you think that we have the tendency to visit more often if somebody has initiated us ?
TC 00:36:36.030 - 00:36:39.040

Simon (yes) either we talk about information so as to be able to see the painting
TC 00:36:42.820 - 00:36:46.070

Simon to evaluate it, to say whether we like it or not
TC 00:36:46.440 - 00:36:50.240

Simon but it is also (museum visiting) an habit
TC 00:36:54.170 - 00:36:57.330

Simon either we talk about a museum or another environment, I mean that….
TC 00:36:57.440 - 00:36:58.970

Elise this can be applied to the entire cultural domain, if we don't have the habit to go to the theatre
TC 00:37:05.420 - 00:37:09.740

Elise when we are young we will not (necessarily) go when we are older
TC 00:37:10.000 - 00:37:13.390

moderator what is the most difficult thing once we are in a museum ?
TC 00:37:16.810 - 00:37:19.890

Marlene you have to understand the works (objects)
TC 00:37:31.140 - 00:37:33.620

moderator understand the works, yes this is important…
TC 00:37:33.780 - 00:37:35.620

Florence even if you are initiated and have visited museums
TC 00:37:41.330 - 00:37:44.290

moderator could you please talk a bit louder?
TC 00:37:44.770 - 00:37:46.980

Florence I say that even if you are initiated and have the habit to make cultural visits
TC 00:37:51.290 - 00:37:53.320

Florence you do not necessarily understand all the works
TC 00:37:57.670 - 00:38:00.760

moderator (Florence seems to be quite intimidated at this point)
TC 00:37:58.080 - 00:37:59.670

moderator when you are in front of a work and you do not manage
TC 00:38:06.470 - 00:38:09.490

moderator to « decode » it
TC 00:38:14.090 - 00:38:16.560

moderator which are your feelings ?
TC 00:38:18.380 - 00:38:20.660

Elise suddenly we don't feel at our place
TC 00:38:25.620 - 00:38:27.210

Marine yes
TC 00:38:27.120 - 00:38:28.020

Marine me, I try to understand, but
TC 00:38:28.130 - 00:38:31.270

Marine apparently, pfff...
TC 00:38:36.460 - 00:38:38.730

Marine well, we let go… (meaning "we abandon")
TC 00:38:40.510 - 00:38:42.920

Marine because if we don't have someone or something to help us…
TC 00:38:42.960 - 00:38:45.230

Marine there are historical references and everything…
TC 00:38:46.120 - 00:38:49.610

Marine we are not supposed to know everything…
TC 00:38:49.830 - 00:38:53.060

moderator of course not…
TC 00:38:52.310 - 00:38:53.720

Marine no, but it's clear
TC 00:38:54.330 - 00:38:56.370

Marine it's for this reason that it is good to have guides (meaning multimedia guides) or things like that
TC 00:38:56.370 - 00:39:00.180

Johan me, I am not disturbed…
TC 00:38:58.210 - 00:38:59.930

Johan even if I don't understand, and I get pleasure just by watching
TC 00:39:00.480 - 00:39:03.230

Johan I am not blocked to go to a museum
TC 00:39:03.580 - 00:39:06.390

Johan without any explications (meaning « interpretation media ») and see things and then
TC 00:39:06.660 - 00:39:08.930

Johan I make my own story
TC 00:39:08.950 - 00:39:10.730

Johan even if I don't have any explication it will not
TC 00:39:10.920 - 00:39:13.490

Johan necessarily disturb me more than that
TC 00:39:13.610 - 00:39:16.060

Johan I am happy, I have seen things
TC 00:39:16.060 - 00:39:17.900

Johan I've seen a work
TC 00:39:20.300 - 00:39:21.810

Florence   yes, because at times having an explanation might guide our vision of the work
TC   00:39:21.810 - 00:39:23.740

Johan   yeah
TC   00:39:23.820 - 00:39:24.490

Florence   while if we have nothing
TC   00:39:25.420 - 00:39:27.650

Florence   we are just in front and it is our imagination that makes everything…
TC   00:39:27.650 - 00:39:29.810

…………………………………………………

moderator   (introducing the subject of the content provided through the AR guide)
TC   00:49:10.570 - 00:49:14.560

Elise   the two things that I found most funny
TC   00:49:36.140 - 00:49:39.400

Elise   it was when we had these « stains » on the painting
TC   00:49:47.440 - 00:49:50.720

Elise   and suddenly we saw..hem…
TC   00:49:50.800 - 00:49:54.050

moderator you mean the infrared photos ?
TC   00:49:53.820 - 00:49:55.550

Elise   yes, exactly !
TC   00:49:55.550 - 00:49:57.830

Marine   yes, that was very nice…
TC   00:49:56.920 - 00:49:59.090

Elise   and the other thing was…
TC   00:49:59.420 - 00:50:02.760

Elise   when the guide focused in small parts of the painting
TC   00:50:02.820 - 00:50:05.970

Elise   some small parts (meaning « the details ») and suddenly we saw things that we had not seen (meaning "observed")
TC   00:50:06.250 - 00:50:09.440

Elise   it drew our attention on the details not on the painting as a whole
TC   00:50:09.670 - 00:50:13.140

moderator   Johan?
TC   00:50:27.460 - 00:50:28.410

Johan   I really liked the details
TC   00:50:28.600 - 00:50:30.720

Johan   but the infrared photos do not speak to me, I don't know if I saw that or not
TC   00:50:30.990 - 00:50:34.260

Johan   or if I did, it did not mark me
TC   00:50:35.490 - 00:50:37.430

…………………………………………………….

Marine me I would say that we should have a headset because at times...
TC 00:51:35.350 - 00:51:37.490

Johan yes, this is very important, it's not that it would be more funny but…(he means "it is necessary")
TC 00:51:37.500 - 00:51:39.760

moderator (other participants agree on that point… Florence, Marlene)
TC 00:51:38.490 - 00:51:40.330

Marlene (Marlene reproduces the move of approaching the guide close to the ears to listen the commentaries)
TC 00:51:46.790 - 00:51:48.640

Johan (Johan as well...)
TC 00:51:48.540 - 00:51:49.910

Johan and then we can not see the images because we are like that (meaning "we have to approach the guide to our ears and holding this position we can not see the content passing by)
TC 00:51:49.910 - 00:51:51.880

…………………………………………………….

Simon I also started feeling pain in the shoulders (meaning "from holding the device")
TC 00:53:28.640 - 00:53:31.580

Marine I don't know, personally I did not have any problems with that
TC 00:53:39.900 - 00:53:42.300

Marine it did not tire me because…
TC 00:53:42.370 - 00:53:44.510

Johan me, I directed the camera towards the painting
TC 00:53:44.250 - 00:53:46.140

Marine yes but you could just activate « pause »
TC 00:53:46.080 - 00:53:47.820

Elise yes, you had to use the « pause » button
TC 00:53:48.260 - 00:53:49.680

Elise what was quite long actually was the text
TC 00:53:51.610 - 00:53:55.330

Elise maybe because we expect something more interactive
TC 00:53:55.330 - 00:53:58.630

Elise we know that there is sound, that there are images, and things that pass by in parade
TC 00:54:02.610 - 00:54:05.100

Elise and it is touch sensitive as we have to touch the on-screen buttons
TC 00:54:05.710 - 00:54:07.350

Elise so we don't really expect to read
TC 00:54:13.700 - 00:54:16.090

Elise for reading I personally prefer to use paper guides
TC 00:54:16.090 - 00:54:18.050

Elise so when I found text I knew I would not really spend time on that
TC 00:54:18.520 - 00:54:20.310

Marlene personally I prefer the text
TC 00:54:20.300 - 00:54:21.600

Marlene because, well..
TC 00:54:21.650 - 00:54:22.970

Marlene I can concentrate on that
TC 00:54:23.110 - 00:54:24.430

Marlene while the audio commentaries I could not hear them
TC 00:54:24.600 - 00:54:26.730

Marlene while the texts...if I don't understand
TC 00:54:27.460 - 00:54:30.440

Marlene I can reread
TC 00:54:33.160 - 00:54:34.810

Marlene it is actually easier for me
TC 00:54:36.580 - 00:54:38.480

moderator and if you had the possibility to personalize the guide
TC 00:54:47.960 - 00:54:50.330

moderator can you see any criteria that could be useful
TC 00:54:59.260 - 00:55:01.990

moderator for personalization ?
TC 00:55:03.010 - 00:55:04.770

……………………….

Johan me, I was expecting something more interactive
TC 00:55:35.170 - 00:55:38.600

Johan regarding the paintings, while there, once we had captured the painting
TC 00:55:44.750 - 00:55:47.190

Johan our eyes were fixed more on the screen than on the painting
TC 00:55:47.340 - 00:55:50.660

Johan and then I told myself that I could have as well stayed home in front of my PC
TC 00:55:50.660 - 00:55:53.270

Johan and visit the museum virtually
TC 00:55:53.320 - 00:55:54.680

Johan it would be the same thing
TC 00:55:54.870 - 00:55:56.510

Marine then to have the computer in between us and the painting
TC 00:56:02.000 - 00:56:04.490

Marine it kind of "cut" things because we were not looking at the painting any more
TC 00:56:04.710 - 00:56:07.280

Marine we felt like being able to place the computer somewhere and just stay in front of the painting
TC 00:56:07.290 - 00:56:09.590

Florence me I did not have at all this impression because
TC 00:56:09.570 - 00:56:11.780

Florence thanks to the "description"
TC 00:56:12.330 - 00:56:14.950

Florence when we had the "description" and all this information
TC 00:56:15.630 - 00:56:17.210

Florence I find this exciting, to be able
TC 00:56:17.480 - 00:56:19.610

Florence to hear what the commentaries said
TC 00:56:19.840 - 00:56:22.120

Florence and be able to see the work for real
TC 00:56:22.240 - 00:56:24.260

Florence yes, like "you can see that there" and also be able to see the details and everything
TC 00:56:24.260 - 00:56:26.450

Marine yes in terms of explications (meaning "comments") you are right,
TC 00:56:29.940 - 00:56:31.680

Marine it is on another level that me I had the impression
TC 00:56:32.040 - 00:56:33.410

Marine that there was...well...
TC 00:56:33.550 - 00:56:34.810

Marine the impression of not being in front of the painting
TC 00:56:34.850 - 00:56:37.240

Simon the fact of having the painting on the screen
TC 00:56:39.310 - 00:56:41.130

Simon me I'd rather have nothing (meaning "not having the painting2) on the screen
TC 00:56:44.300 - 00:56:47.360

Simon at least at this moment
TC 00:56:49.550 - 00:56:50.430

Simon like that I would have looked at the painting
TC 00:56:53.070 - 00:56:54.920

Simon while here there were moments where I only looked the guide
TC 00:56:55.040 - 00:56:57.290

Simon and after a while I asked myself why I was looking on the screen
TC 00:56:59.740 - 00:57:02.360

Simon having this thing in between my hands
TC 00:57:03.800 - 00:57:06.390

Simon and the fact that everything came from there
TC 00:57:06.580 - 00:57:08.370

Simon there were moments I just forgot the painting
TC 00:57:08.370 - 00:57:10.950

Simon that was in front of me
TC 00:57:13.100 - 00:57:14.780

moderator Elise, what were your feelings as to this issue?
TC 00:57:14.810 - 00:57:16.910

Elise Personally, I was not blocked on the screen
TC 00:57:16.040 - 00:57:18.200

Elise I was going from the screen to the painting as…
TC 00:57:24.410 - 00:57:27.130

…………….