Combining modern multimedia and internet technologies to enhance museum visits and visitor involvement through a Virtual Museum.

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Abstract

This master thesis describes how modern multimedia an internet technologies can be combined to enhance museum visits and visitor involvement through a Virtual Museum. Museums have lots of information available about their collections, but have difficulties in presenting a visitor with useful information. Museums want to involve visitors interactively before, during and after a museum visit in order to attract people to (re)visit the museum and to learn from the visitors' behavior. The Virtual Museum is a concept developed to address this need, and is a complete package consisting of an information assistant for museum visitors, a content creation program, a website and a data analysis tool for the museum. The scope of this report is the design of the Virtual Museum in general, with specific attention being given to the user interface and functionality of the information assistant. The information assistant provides a visitor access to context-aware and personalized information, while the website serves to expand the museum experience. Bookmarking is used as a means of linking the information assistant and the museum website.

The results of this master thesis are a working prototype of the information assistant, guidelines and specifications for the design of Virtual Museums and a new prototyping method that can be used on the PDA (chosen as the platform for the information assistant) to fill the gap between paper prototyping and programmed prototypes.

A demo with the Information Assistant has been conducted in a museum, the Twents Techniekmuseum HEIM, to test the design of the user interface and the map used to navigate through the information in the Assistant and through the physical space.

The report contains guidelines and requirements for similar projects and similar products. The two guidelines that are considered the most important are (1) that the museum staff must be enthusiastic about the product in order to promote it to visitors, and (2) that the content is the most important part of the Virtual Museum. The content must be up to date, and divide the attention between the Information assistant and the museum objects.

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Chapter 1

Introduction

This master thesis is written as a graduation assignment for the study Industrial Design Engineering, Management of Product Development, at the University of Twente in the Netherlands. This graduation assignment has been executed in cooperation with Twents Techniekmuseum HEIM (TTH) at the company Siteseeing Internet Services (SIS), both located in Hengelo.

This thesis describes how to combine modern multimedia and internet technologies to enhance museum visits and to increase visitor involvement.

1.1 Motivation

Twents Techniekmuseum HEIM (TTH) shows the development of industrial technology in Twente, in her collection of restored and working machines, scale models and historical background information provided by volunteers. Siteseeing Internet Services (SIS) is a web-based solutions provider and Consultancy Company based in Twente, and as such partner of TTH.

The museum has a lot of information available about the collection, for instance on the use and repair of machines, cultural and historical background and development. It is difficult to adequately present and absorb this information during a single museum visit. The museum would ideally cater exactly that information that each visitor would like to receive, and would (inter)actively involve the visitor not only during, but also before and after a visit to the museum.

Traditional static information in museums, such as signs and audio tours, are confined to the museum properties, are not easy to update or personalize, are very limited in freedom of presentation and can not be used to collect information from the visitors. This is where interactive multimedia and internet technologies could be used, to create a 'Virtual Museum' as a seamless extension to the physical museum (see figure 1.1).

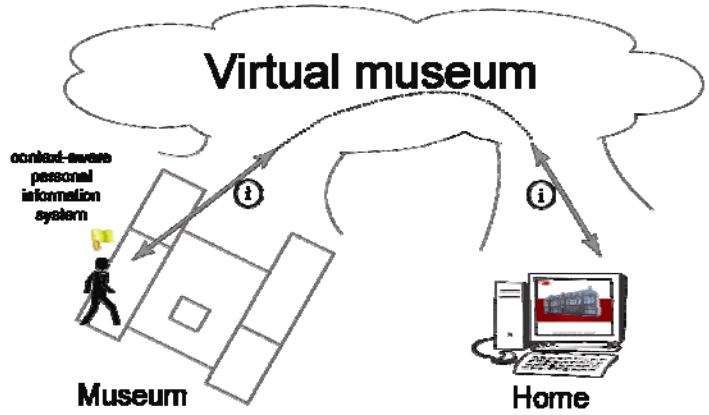


Figure 1.1: *The Virtual Museum*

In the Virtual Museum of TTH, the visitor could for instance prepare his visit by browsing multi-media background information; plan a route based on personal preferences; take a virtual tour through the museum; bookmark things that interest him during a visit; subscribe to newsletters or contribute to the body of information with his own knowledge.

The Virtual Museum could thus provide a rich and exciting multimedia experience, which attracts people to (re)visit the museum and share their experiences with the museum and other visitors. It should be an interactive extension to the 'real' museum, and should adapt to personal preferences, location and type of media used.

During the visit, localization information (obtained either actively or passively) could also be used to help visitors acquire information related to their direct environment.

1.2 Objectives and requirements

The purpose of this graduation assignment is twofold. First, to advise on general and specific requirements and solution alternatives, and to devise guidelines, scope definitions and a working prototype for a web-based platform for the Virtual Museum of TTH. Second, a product should be designed that can act as a personal context-aware information system to visitors during a museum visit. The following items are treated:

- Investigate which new technologies can be used by museums to interactively convey information and involve visitors, before, during and after a museum visit.
- Write guidelines and specifications for the development, and build prototype(s) of a Virtual Museum for Twents Techniekmuseum HEIM.
- Design a product that can act as a personal context-aware information system to visitors during a museum visit.

Requirements

The Virtual Museum of TTH should at least contain, connect and provide easy and consistent access to the following components:

- a personalized context-aware multimedia tour in the museum,
- 'bookmarking' in the museum and reviewing at home.

Furthermore, the Virtual Museum should allow for integration of:

- an online library catalog,
- an online multimedia catalog of items in storage,
- historic pictures and photo's,
- interviews with volunteers explaining,
- a platform for contributions from the public.

The following items are the deliverables of this report:

- Specifications and guidelines for each component above and for each medium to be used for the Virtual Museum, considering (personalized) content, user interaction, functionality, integration and user interface(s).
- Specifications and guidelines tailored to the stakeholders that would result in an integrated Virtual Museum with a universal but distinctive look and feel across the various current and future components.

1.3 Research questions

Background research should answer and report on the following:

1. What are the technical descriptions, backgrounds, and pros and cons of systems in use?
2. What can museums gain by new ways of presenting information?
3. What are the challenges in delivering personalized information to visitors?
4. What are the needs and opportunities of different stakeholders of TTH (e.g. employees, visitors, students, children, businesses, sponsors, community, the public, the city, founding fathers, ...)?

1.4 Approach

The graduation assignment 'Combining modern multimedia and internet technologies to enhance museum visits and visitor involvement through a Virtual Museum' consists of several parts which are explained using the roadmap in figure 1.2.

The first part of the assignment is an investigation of the subject; this part consists of a visit to the *research* room, the *brainstorm* hallway, the *stakeholder analysis* room and the *user study* area. The second part is the design phase in which the *brainstorm* hallway is visited three times. The *generate concepts* room, *scenario of use /use cases* hallway and the *discuss with stakeholders* room will also be visited at least three times during the design phase. The next phase is a more detailed exploration of the concept(s) by visiting the *low-fidelity (lo-fi) prototyping* room and again the *user study* area. At the end, one concept has to be chosen when leaving the *choose between concepts* hallway. This final concept goes into the evaluation phase. It passes the *heuristic evaluation* room (where the concepts will be evaluated with the use of usability principles) and the *prototyping* room, and then it will visit the *user study* area. If the investigation phase, design phase, detail design phase and evaluating phase are all walked through the result will be a final product, the virtual museum.

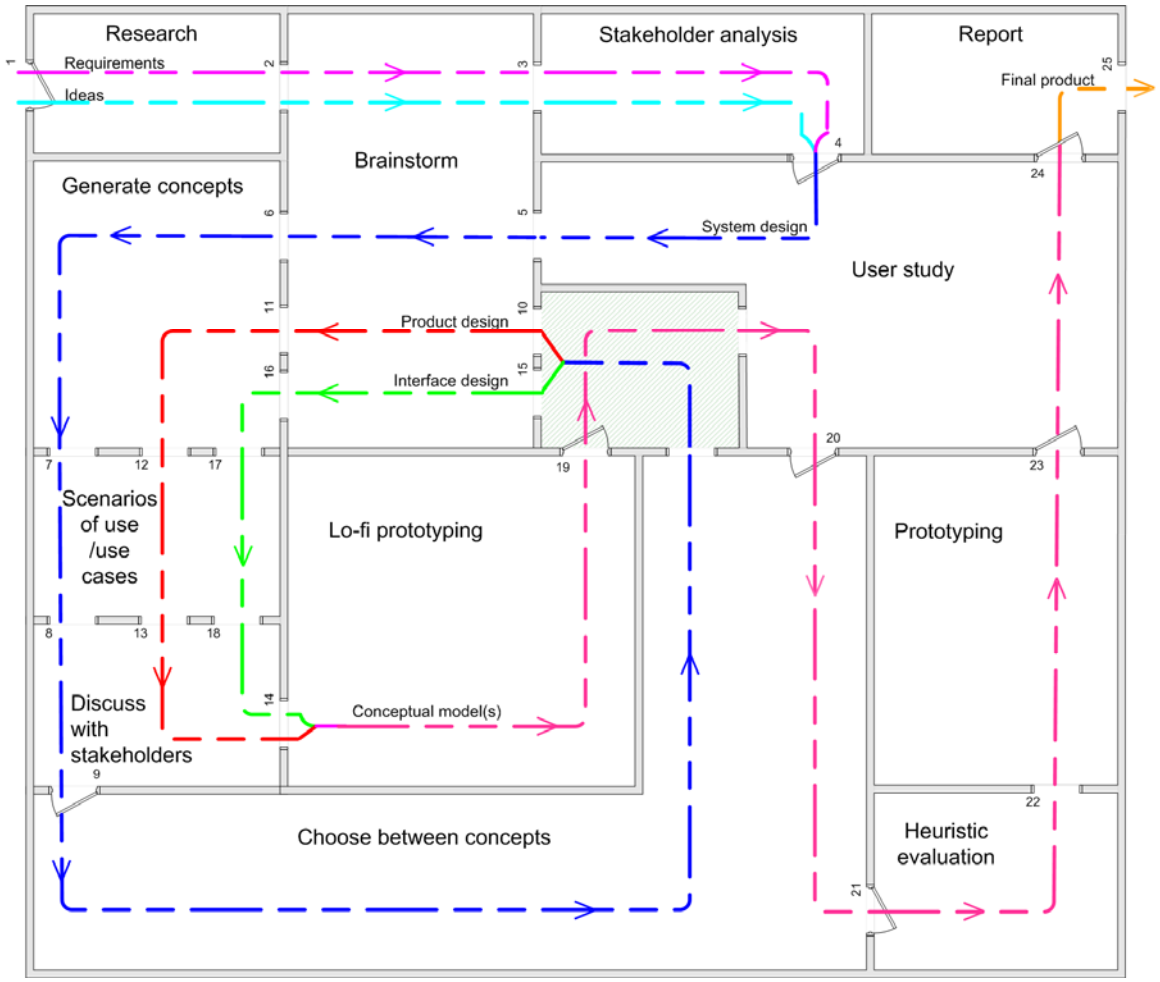


Figure 1.2: *Roadmap*

1.4.1 The route

The first step is collecting requirements and ideas. These are gathered by background *research*, *brainstorming* and *stakeholder analysis*. The requirements and ideas are used in the first *user study*. After the user study a *brainstorm* is done on the system design in general. All the ideas and requirements are used to generate *concepts*. These concepts are tested in *scenarios of use* and translated into *use cases*, to determine which concepts are feasible. The concepts that pass this step are *discussed with the stakeholders*. Following this, one *concept is chosen* and split up in a product design and an interface design track. Again a *brainstorm* is carried out, this time for the product design and for the interface design separately. For these designs concepts are generated, which will be placed in *scenarios of use* and translated into *use cases*. The designs with great potential *are discussed with the stakeholders*. After this, the product and interface designs are joined together into one or more conceptual models. From this conceptual model *lo-fi prototypes,* like paper prototypes, are made which will be used in a *user study*. If there is more than one conceptual model at this time, one has to be chosen. On this *chosen concept* a *heuristic evaluation* is conducted. Then a *prototype* is built of the virtual museum which will be tested during a *user study*. When the product passes this stage it has become the final product which will be discussed in a *report*.

During this project, an iterative design approach will be used. There will probably be several iterations before moving on to the next room. However, the design process can always track back further if it isn't able to pass a room.

1.4.2 The rooms

The roadmap consists of 12 rooms. These are 12 different project steps and some of them are passed more than once. Each room has inputs (the entrance) and outputs (the exit), visualized by numbered doors. The roadmap will now be explained room by room.

Research

Through research the following questions (from section 1.3) have to be answered:

1. Which new technologies can be used by museums to interactively convey information and involve visitors, before, during and after a museum visit?
2. How and what can museums gain by new ways of presenting information?
3. What are the challenges in delivering personalized information to visitors?

The resources used to answer these questions are: academic articles, professional museum magazines, professionals in the business and investigation through museum visits. The product of the research room consists of the answers to these questions, which results in a set of requirements and ideas.

Brainstorm

The brainstorm hallway is passed four times. The first brainstorm is the widest in scope. Subjects to brainstorm about in this phase are:

- Outputs of the research part.
- Possible markets for the end product.
- How to provide context aware information to the visitor and with what kind of medium.
- How the virtual museum will act and look.

After generating ideas, colleagues are asked to participate to get input from people with different backgrounds. The outputs of this first brainstorm are ideas and requirements.

The second brainstorm concerns the system design. The inputs are all the requirements and ideas so far. Subjects in this phase are:

- The virtual museum as a whole.
- A personalized context-aware multimedia tour in the museum.
- How to bookmark objects and how to review them at home.
- Archiving skills, technical knowledge and a sense of craftsmanship of the museum's volunteers.
- Platform for contributions from the public.
- Ways of fulfilling the requirements.

The outputs are used to generate concepts.

The third brainstorm concerns the product design. The input is the system design, the ideas and requirements. This one is more focused on a specific subject than the first two brainstorms. The fourth and last brainstorm concerns the interface design.

Stakeholder analysis

By interviewing stakeholders, a stakeholder analysis will be made to clarify the needs and opportunities of different stakeholders of TTH (e.g. employees, visitors, students, children, businesses, sponsors, community, the public, the city, founding fathers, ...). This will answer research question number 4.

User study

User studies are conducted to clarify needs and opportunities and to test concepts. Also, user studies involve volunteers and staff members of TTH, colleagues of SIS and museum visitors with the project. Market research (section 2.1.3: Changes and challenges) pointed out that for successful marketing the museum and its employees have to be enthusiastic about the system; involving them makes it more likely that they will be enthusiastic about the system.

User studies will be performed at three distinct moments during the project. The first user study consists of interviews with possible users. Potential users are asked what they would want to do with a context-aware personal information system and how they want to use it. These interviews are used to create scenarios for the Virtual Museum and the personalized context-aware multimedia tour in the museum.

The second user study is carried out with lo-fi prototypes of the Virtual Museum that are the result of the previous room. Changes can be made directly during the user study. This iteration between lo-fi prototyping and user studies is finished when no more problems occur during the user study. The outcomes of this step are one or more detailed concepts.

The third and last user study is conducted with working prototypes of the Virtual Museum. The product will be used by users in a museum, after which it is evaluated and corrected where necessary.

This will result in the final product, the Virtual Museum.

Generate concepts

The generate concepts room is visited three times. The first time concepts are generated for the *system design*. The second time for the *product design* and the third time for the *interface design*.

The first time concepts are generated for the system design using input from the brainstorms, the user study, research and stakeholder analysis rooms. The outcome is a concept for the Virtual Museum as a whole. On the second visit, the product design route passes this room. This time the input is a concept of the system design and the results of the brainstorm about product design. The outcome is a concept for the product. The third time, the interface design route passes the concept generating room. The inputs are again the system design and the results of the brainstorm conducted on the interface design, while the outcomes are one or more concepts for the interface of the product.

The second en third concept generating steps are very much connected because together they have to form the Virtual Museum. But because one is a physical product and the other one is digital the concept generating phase will be different so they are separated.

Scenarios of use / use cases

In the design phase scenarios are used to evaluate ideas and as a communication tool to the stakeholders. The concepts that come out of the *generate concept* room are tested in scenarios and translated into use cases. If problems occur in the scenarios, the concept is sent back for adjustments to the *generate concepts* room. Concepts that fit in the scenarios can leave the *scenarios of use /use cases* hallway through the exit.

Discuss with stakeholders

The scenarios of use and the use cases that enter this room are discussed with the stakeholders. If adjustments have to be made the concepts are sent back to the *generate concepts* room or further back if necessary. The system design concepts that are approved go on to the *choose between concepts* hallway. The product design concepts and the interface design concepts that are approved go on to the *lo-fi prototyping* room.

Lo-fi prototyping

In this room the product design and the interface design routes are merged. At this moment there can be more than one conceptual model. From those conceptual models low fidelity prototypes are made. Problems that occur while creating these can be corrected immediately. If necessary, the concept is sent back on the route or thrown away if the other concepts are superior. The low fidelity prototypes that result from this step are used in the second user study.

Choose between concepts

When more than one system design is approved by the stakeholders a choice has to be made. This is done in the *choose between concepts* hallway by comparing the concepts with the requirements.

Heuristic evaluation

A heuristic evaluation is an evaluation of the usability of a user interface by examining it using usability principles. Because different evaluators can find more usability problems than one evaluator, I will also ask other people to do this heuristic evaluation. The usability problems that come up during the evaluation have to be corrected before moving on.

Prototyping

During this project a new rapid prototype tool has been invented, so called ‘digitized paper prototyping’ to fill the gap between paper prototyping and coded prototyping. More information about this tool the author developed can be found in section 8.2, a step by step explanation about how to use the tool can be found in Appendix A.

From the Multimedia Guide a working prototype will be built so it can be tested during the third user study. While building the prototype new problems will probably occur which have to be fixed before moving on.

Report

During the project this report has been written, together with the virtual museum this represents the end product of my graduation assignment. This report describes all the steps in the project and a plan for the actual implementation of the virtual museum.

1.5 Structure

The report has been divided into three parts:

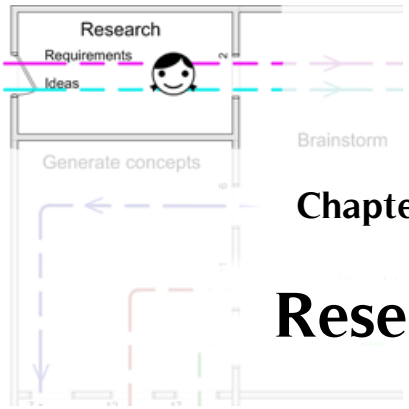
Part 1, Research, contains background research (chapter 2), an investigation of the user needs (chapter 3) and the projects requirements (chapter 4).

Part 2, Design, describes the design phase which starts with generating a concept for the Virtual Museum (chapter 5). For the chosen concept, scenarios of use and use cases (chapter 6) are written. Chapter 7 describes the system design consisting of a Configuration System, Location Based Services (LBS), a handheld device, a website, a front desk and a content framework. Three different phases of prototyping, paper prototyping, the newly designed digitized paper prototyping and coded prototyping are clarified in chapter 8.The design of the interface and its elements are described in chapter 9.

In **Part 3, Evaluation,** the final product has been evaluated by means of the requirements and guidelines formulated during the project and by means of the results of a demonstration given at the Twents Techniekmuseum HEIM, this is described in chapter 10. The conclusion with recommendations is given in chapter 11.

Part 1: Research

Part 1 is the research phase. Chapter 2 describes the conducted market research and research on similar projects to answer the first three research questions. The fourth research question is answered in Chapter 3 about User needs, the needs of museum visitors, the museum itself and the City are revealed in this chapter. Chapter 4 sums up all requirements for the Virtual Museum.



Chapter 2

Research

As stated in section 1.3 (Research questions), background research should answer and report on the following:

1. What are the technical descriptions, backgrounds, and pros and cons of systems in use?
2. What can museums gain by new ways of presenting information?
3. What are the challenges in delivering personalized information to visitors?
4. What are the needs and opportunities of different stakeholders of TTH?

Market research (section 2.1) has been conducted to answer the first three research questions. The fourth question concerns the user's needs and will be treated in the next chapter (3 User needs).

While doing literature research, systems were found of which we did not know the existence. Only a few systems can be found in museums nowadays, and you have to specifically ask for them when you visit the museum. Nine viable systems are treated in the market research. Because we really don't want our project to be forgotten in a few years, or never to be implemented at all, we have to know where other projects have gone wrong. Investigation on this part can be found in section 2.2: Similar projects.

2.1 Market research

Market research should give insight into which new technologies are used by museums to interactively convey information and involve visitors, before, during and after a museum visit. The product that is to be designed should be able to act as a personal and context-aware multimedia tour during the museum visit. It is therefore important to know how and to what extent existing systems provide personalization and context-awareness, and what media is used. The product should also involve

visitors before and after the museum visit; background research will therefore also focus on the options currently available and in use to extend the experience to before or after the museum visit.

From the point of view of the museum it is important to know how much and what type of maintenance is needed to keep the multimedia tour working and up to date. To obtain information about visitor behavior, data must be collected from the museum tour and some kind of data analysis must be possible in order to turn the data into information. Experiences of museums with multimedia tours can give insight into the challenges of delivering personalized information to the visitors and the pros and cons of existing systems.

From the point of view of the museum visitor, the interface of the multimedia tour is his main point of interaction. It is therefore important to investigate the look and feel and ease of interaction with the interface. To be able to determine if a multimedia tour is able to enhance the museum visit, it is important to record visitor experiences.

One last aspect that deserves special attention when investigating existing systems is the division of the user's attention between the multimedia tour and the surroundings. Because multimedia tours use the same visual channel as the exhibition, multimedia tours are in essence in conflict with the exhibition. According to DI Jochen Martin from FH Joanneum Gesellschaft mbH, who worked on the SCALEX project [2], this can be the reason why multimedia tours are not yet successful.

2.1.1 Existing Multimedia Guides

To be able to answer the first three research questions (see section 1.3) the existing systems in table 2.1 are evaluated on the following aspects:

- **Technology**: which new technologies are used.
- **Context-awareness**: how and to what extent the multimedia tour is aware of its location.
- **Media**: what type of media is used.
- **The user interface**: how to interact with the multimedia tour.
- **Attention division**: how the user's attention is divided between the multimedia tour and the surroundings.
- **Personalization**: how and to what extent can the multimedia tour be personalized.
- **Before and after the visit**: how can the museum experience be extended to before and/or after the museum visit?
- **Visitor experiences**: to determine if a multimedia tour is able to enhance the museum visit.
- **Maintenance**: how much and what kind of maintenance is needed to keep the system working and up to date.
- **Data analysis**: how to collect information about visitors and get insight into visitor behavior.
- **Experiences of museums**: Get insight into the challenges in delivering personalized information to the visitors and the pros and cons of the system.

Extensive descriptions and references for the following systems can be found in Appendix B.

Product name	Company	Museum/facility
GuideID	Guide ID	Museum Boijmans Van Beuningen, Rotterdam CODA Museum, Apeldoorn
Antenna Audio	Antenna Audio	Van Gogh Museum, Amsterdam Tate Modern, London
VUEguide	Ubiquity Interactive	Museum of Anthropology (MOA), Vancouver
SCALEX	University of Applied Sciences FH Joanneum, Graz	Zentrum für Kunst und Medientechnologie (ZKM), Karlsruhe
Camineo	Camineo	Ecomare, center for Wadden and North Sea, Texel Island
Narrator	Touchport	Museum Vleeshuis, Antwerp
Droombeek	Droombeek foundation	the district Roombeek, Enschede
Codex	Hootchie Cootchie Mediacollectief	the district Delfshaven, Rotterdam
GUIDE	University of Lancaster	City of Lancaster

Table 2.1: *Existing systems*

The companies involved in the investigated systems have diverse backgrounds. Some are rooted in European research projects and university projects, while others produce audio guides and content, documentaries and multimedia or storytelling technologies.

GuideID

The GuideID multimedia museumguide is a product of the Dutch company GuideID. Visitors are equipped with a PDA, carried around the neck, that gives multimedia information about objects in the exhibition. The system comes with a box to charge and update the PDAs, a Content Management System, infrared tags and a Management Information System [3]. Several museums and other organizations use or have used the GuideID system. Information about the GuideID has been collected by testing the system in two museums, the CODA museum and the Boijmans van Beuningen. Some pictures made during testing can be seen in figure 2.1. Furthermore, three museums, a zoo and a photo exhibition organization that have used the device in the past have been asked for their opinion.

Figure 2.1: *Photographs, made in Boijmans van Beuningen and Coda Museum.*

Antenna Audio

The Dutch Van Gogh museum and London's Tate Modern use a multimedia guide by the English company Antenna Audio, the leading provider of audioguides. The multimedia guide is an application on a PDA that can be carried in the hand or with a cord around the neck and gives multimedia information about objects in the exhibition. Information about the multimedia guide has been collected by testing the system in The Van Gogh museum, which uses both the audio and multimedia guide from Antenna Audio. And by research papers and other published information about the Tate Multimedia guide. Figure 2.2 shows some pictures of the interface used in the Van Gogh Museum and some of the interface used at Tate Modern.

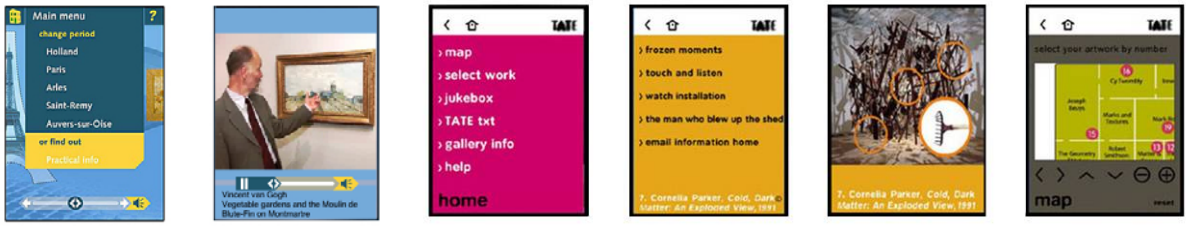


Figure 2.2: *Pictures from Antenna Audio.*

VUEguide

The VUEguide, which is displayed in figure 2.3, is a product of the Canadian company Ubiquity Interactive. The VUEguide devices are PDAs with an extra large battery pack and are packed in a custom casing. They respond to infrared signals emitted by location beacons placed throughout the main galleries when the device is pointed at the tags. The system from Ubiquity Interactive was installed at Vancouver's Museum of Anthropology (MOA) from the Spring of 2005 through to Fall 2007. Information on the VUEguide has been collected by using press releases and papers and by email contact with Jennifer Webb, Communications Manager at MOA and Leora Kornfeld, principal of Ubiquity Interactive.

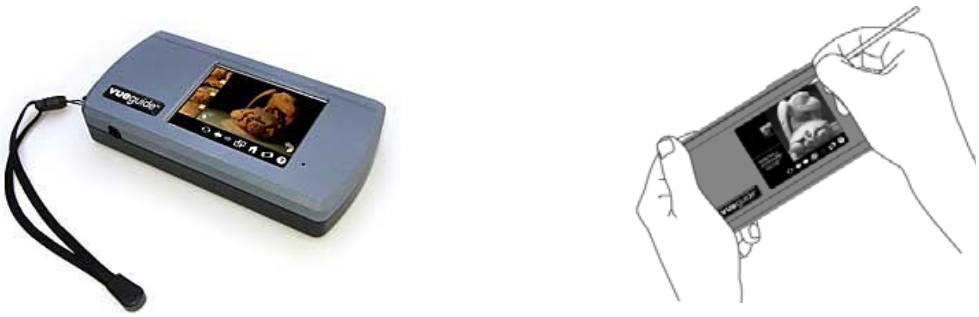


Figure 2.3: *Pictures form Ubiquity Interactive.*

SCALEX

SCALEX is a scalable exhibition server with which museums can publish digital content in exhibitions. It consists of several components: a Knowledge Editor, a Storyliner, a Player and a Profiler [4]. Figure 2.4 shows a picture of the Player and the Profiler. The SCALEX project was supported by the European Commission. The project was carried out jointly by 11 institutions from 5 countries, coordinated by the department of Information-Design at the University of Applied Sciences FH Joanneum, Graz, Austria [2]. Information about the SCALEX project has been collected from papers and by email contact with DI Jochen Martin from FH Joanneum Gesellschaft mbH and Miriam Stürner from Zentrum für Kunst und Medientechnologie (ZKM) in Karlsruhe.

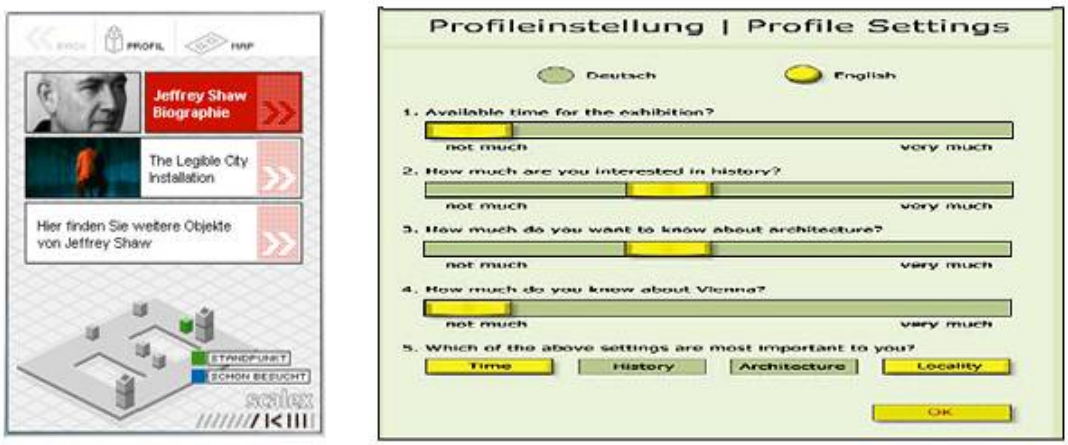


Figure 2.4: *From www.scalex.nl model exhibition 2 at ZKM, and the profiler.*

Camineo

Ecomare, the center for wadden and North Sea on Texel Island, makes use of an outdoor multimedia guides from the French company Camineo to provide visitors with the opportunity to discover the area in a fun and educational way. The system has been developed by Ecomare, Geodan and Camineo and funded with European Innovation subsidies [5]. The visitor devices are PDAs with a keycord, which can be viewed in figure 2.5. The museum can create and update content itself using the Camineo CMS. Information about the Camineo guide at Ecomare has been gathered by testing the system and interviewing Oscar Bos of Ecomare.

Figure 2.5: *Photographs, made at Dunepark Ecomare.*

Narrator

Museum Vleeshuis in Antwerp Belgium provides every visitor with a multimedia tour on a PDA, called the "Narrator" (see figure 2.6). Behind the counter, a wall full of PDAs are waiting for visitors. A screen on the counter gives information about the device. The platform, Touchport, provides tools to create and update content over the internet and options to personalize a tour. Information on this system has been collected by testing the Narrator and questioning counter staff.

Figure 2.6: *Pictures from Museum Vleeshuis.*

Droombeek

The Droombeek foundation strives to stimulate communication in and about the district Roombeek in Enschede, and preserving the past, present and future of the district and its inhabitants. For this purpose a platform has been developed consisting of an interactive website and handheld guides which provide a tour through the Roombeek district. Information about the handheld guides, from which the interface is displayed in figure 2.7, is gathered by testing the tour and by interviewing Peter Dubois of the Droombeek foundation.

Figure 2.7: *Pictures from the Droombeek interface.*

Codex

Codex Delfshaven is a project from Hootchie Cootchie Mediacollectief. Visitors receive a PDA with headset, these products are displayed in figure 2.8. The PDA shows a graphical map of the district Delfshaven. A separate satellite map is provided on paper for orientation and navigation. This paper map is full of red dots, spots were audio fragments, and sometimes, pictures are available. Information about the Codex handheld has been collected by testing it and asking questions to the person that gives out the devices.

Figure 2.8: *Photographs, made during Codex tour.*

GUIDE

The GUIDE project from the University of Lancaster has developed a context-sensitive tourist handheld guide for outdoor use. During the project, the guides were available from the Lancaster City Council. Information is obtained by means of a research paper [6], the projects website [7] and email contact with Jane Silvester from the Lancaster City Council. Figure 2.9 shows a screenshot form the GUIDE interface.

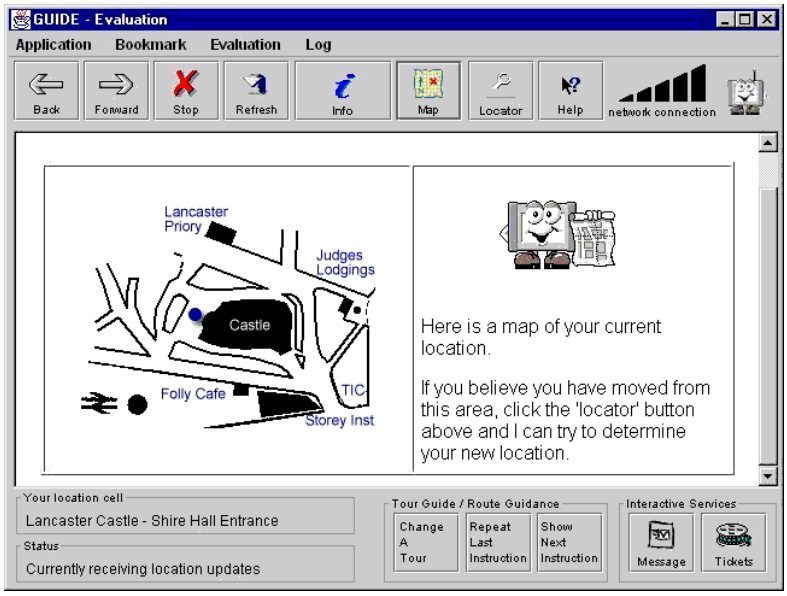


Figure 2.9: *Picture of the Guide interface.*

2.1.2 Pros and cons of systems in use

The pros and cons of systems in use is described from two perspectives: from the point of view of the museums, and from point of view of the visitors. The pros and cons of multimedia guides from the point of view of museums are listed below. This is the result of the experiences of museums investigated in the market research.

Pros - Multimedia guides can:

- disclose large amounts of information;
- tell the stories behind museum objects, the museum itself and for example the museum's building;
- make comparisons between objects and display information related to each other;
- make visitors stay in the museum longer;
- support visitor profiling.

Cons - Multimedia guides:

- can have problems like PDAs that crash;
- be equipped with too many buttons, which behave unexpectedly when being pressed on certain moments or in certain combinations. Visitors explore the device and because of that push buttons from which they are supposed to stay off;
- react very slow on user input (3seconds) leading to visitors that complain towards the museum staff members;
- do not always start up.

Also:

- Museums need to have a desk with trained staff members to give the user explanations and ensure publicity and marketing, but they do not want to need extra know-how to preserve the system;
- The amount of devices that are needed can fluctuate, for example because of the season;
- The used technology can quickly become redundant;
- PDAs can disappear, although users have to give for example a bank account number and signature;
- Visitors might drop the device; this does not have to mean that the device is broken, but it can cause the application to crash.

The pros and cons of multimedia guides tested by the author, from the point of view of the visitors are listed below in table 2.2.

	Pros	Cons
GuideID (Boijmans)	Informative audio, entertaining, nice to listen to. Very simple interface	Play and pause button for audio message are difficult to see in the interface. It is mainly an audiotour, sometimes showing a picture.
GuideID (CODA)	No confusing buttons	It is too heavy to carry around. The exhibition itself was already full of multimedia, this was too much.
Antenna Audio (Van Gogh)	Good looking Good audio voices	No consistent navigation and user interface. Inactive elements are used as navigational elements. The help function is not always present. The application reacts slowly on inputs.
Camineo	Interesting and entertaining, especially the questions.	Constantly be pushed with information is getting irritating.
Narrator	Devices can be synchronized with the flat screens on the wall. Nice music fragments	User receives error messages and script code. Amount of information is sometimes disappointing.
Droombeek	The user has to walk towards the POIs before it can access them. Interesting videos.	It is hard to type messages with the onscreen keyboard.
Codex	Simple interface	There is no zoom option on the map. The digital map does not correspond with the printed map. The pictures in interface are shifted 1 cm.

Table 2.2: *pros and cons of multimedia guides that were tested.*

2.1.3 Chances and Challenges

Communication with the museums during the market research resulted in chances that museum gain by new ways of presenting information, basically this are the reasons to start with the multimedia guides. These chances answer research question 2: "What can museums gain by new ways of presenting information?" For museums, presenting information by combining multimedia and internet technologies allows them to:

1. disclose large amounts of information;
2. tell the stories behind museum objects, the museum itself and the museum's building;
3. make comparisons between objects and display things that are related to each other;
4. provide that visitors stay longer in the museum;
5. support visitor profiling.

Also, Information about visitors can be collected by recording user actions on the devices and by letting users fill in personal data. Insight into visitor behavior can be obtained by registering which objects are examined most and how long visitors stay in the museum. Eventually this could lead to exhibitions and information that is directed better at an individual visitor's interests that will lead to more visitors that (re)visit the museum.

The challenges for museums in delivering personalized information to the visitors are found by asking museums about their experiences with multimedia guide systems. The following people are asked about their experiences:

- Steven Kolsteren, head of education, Groninger Museum, Groningen.
- Drs. Herman Tibosch, head of education, Kröller-Müller Museum, Otterlo.
- Femke van der Valk, staff member exhibitions, World Press Photo, Amsterdam.
- Bertine Lindeboom, spokesperson, Wissel Zoo, Epe.
- Staff members of Museum Boijmans Van Beuningen, Rotterdam; CODA Museum, Apeldoorn; Netherlands Architecture Institute (NAi), Rotterdam.

Challenges encountered by museums:

- Get visitors to use the multimedia guide. People have to know about the existence of the guide. Current multimedia guides are not advertised enough. On most of the websites of museums with multimedia guides that were tested during the market research, the guide was not mentioned or information was hard to find.
- Get visitors to pay to use the multimedia guide. Visitors are enthusiastic about the system when they test them in a user test, but when they have to pay for it the threshold to use one becomes too high.
- Get the museum staff to actively promote the multimedia guide. In most of the visited museums, staff members are not actively trying to promote the devices, because they are not very enthusiastic about the system. This is because the devices have problems or because they have to give an explanation with the device.
- Keeping the system up to date.
- Keeping the guides fully charged. When the devices are often used, problems with the battery life start to occur because there is not enough time to fully recharge the devices.
- Provide the right amount of POIs in a system based on information push.
- Provide the users with a user interface they understand immediately, so they do not have to return to the counter with questions.

These challenges answer research question 3: "What are the challenges in delivering personalized information to visitors?" from the viewpoint of museums. Answer on this research questions from the viewpoint of designers is given in section 2.2.3. With enthusiastic staff members the above mentioned challenges will be easier to tackle. When the staff member are enthusiastic it will be easier to actively promote the guides to visitors and to keep the system up to date and the devices fully charged. A **guideline** that therefore will be used for this project is: The museum's staff members and volunteers should be enthusiastic about the system.

2.1.4 Summary

The aspects on which the systems were evaluated in the market research are used in this table (2.3) to give a small summary on all the investigated systems. How the scores are determined and how the table therefore must be read is listed in the rest of this section below, all scores are relative towards each other.

	GuideID	Antenna Audio	VUEguide	SCALEX	Camineo	Narrator	Droom-beek	Codex	GUIDE
Technology	□	-	□	++	+	-	+	+	+
Context-awareness	□	-	□	+	++	-	++	++	++
Media	+	++	++	+	□	++	+	□	□
The user interface	□	-	NS	NS	+	+	+	- -	NS
Attention division	+	++	- -	NS	++	- -	□	+	NS
Personalization	□	□	NA	++	NA	- -	-	NA	+
Before and after the visit	- -	□	- -	- -	- -	- -	+	- -	- -
Visitor experiences	++	□	+	NS	++	+	+	- -	NS
Maintenance	+	-	- -	NS	□	++	+	- -	- -
Data analysis	□	NA	□	+	NA	- -	NA	NA	NA
Experiences of museums	+	□	+	+	+	+	NS	- -	-

Not studied : **NS**

Not available in the system : **NA**

Table 2.3: A summary of all the investigated system.

Technology: PDAs and tablet PCs are used to provide information towards the user. GPS, infrared, RFID and WLAN technologies are used to create location-awareness or to enter object information. SCALEX uses the most new technologies, like PDAs, RFID, infrared and several back-end components to optimally publish and present digital content based on personal preferences.

Context-awareness: Some of the guides are continually aware of their location, namely Camineo, Droombeek, Codex and GUIDE, they use GPS or WLAN as a positioning technology. The systems that use infrared or RFID tags are location-aware to a lesser extent; at least the user is in the vicinity of the object when the tag is scanned. When the user has to fill in a number, he might stand beside the corresponding object but this is no certainty.

Media: Media types that are used by the researched guides are: Text (small pieces of text, scrollable texts, question/answer games), Audio (spoken texts, music fragments, conversations), Pictures (photos, graphics), Video (movies, animations), Interactive (3D models, interactive panoramas, pictures that can be zoomed in, interactive elements like changing the frame of a painting). All the multimedia tour guides use at least two of these media types.

The user interface: Some guides can be manipulated by finger but for most a stylus is needed. Some only use the touchscreen, others use also one or more of the hardware buttons. Table 2.3 gives an overall result of how good or bad the interface was found after testing them.

Attention division: Dividing the attention is always done by means of the content of the guide. Possible ways are: pinpoint the user to the object by describing a certain fact and tell the user where to look at; tell the user things that he can see in his surroundings; Providing the information is small pieces instead of long texts that require attention; ask the user questions for which the user has to study his surroundings before knowing the answer; use audio instead of text or video so that the user does not have to look at the screen.

Antenna Audio and Camineo paid close attention to this aspect; VUEguide and Narrator do nothing to overcome the fact that users constantly watch the screen.

Personalization: Throughout all the researched systems, users can choose between tours, languages and/or topics. They can fill in their age, interests and tell the system how important they find certain parameters. The SCALEX system can even recognize user behavior and adapt the content based on that.

Before and after the visit: The Tate Modern guide from Antenna Audio has an option to email the information home. All information on the Droombeek guide can also be viewed on the web; people can also leave their stories there and reply on others. During the Droombeek tour position can be marked to leave a story, this story can be typed in on the Droombeek guide or afterwards via the website.

Visitor experiences: Table 2.3 gives an overall result of how visitors experience the guide with regards to enhance the visit. Information about these experiences can be found in Appendix B.

Maintenance: To keep the system working and up to date the devices need to be updated and recharged; therefore a connection has to be provided to a power source for the current and to a computer or network for data transfer. The content has to be maintained and monitored by some kind of agent or agency. The content has to be accurate; this means that changing environments, like flora and fauna, need maintained more intensive. A CMS system can be used to create and manage the content, compose tours and temporarily exhibitions. New content for the guides that arrives , for example, through the museum website must be scanned before putting it into the guides. Table 2.3 gives insight in the ease of doing maintenance for the different guides.

Data analysis: Information can be collected by recording all user actions on the device and by letting visitors fill in some personal data. Insight in visitor behavior can be obtained by Indicating which objects are examined most and determining how long visitors stay in the museum.

The GuideID system is able to do data analysis, but none of the seven facilities that were questioned during the market research used this feature. The VUEguide devices record all user actions, but the museum (MOA) had not yet used this information. SCALEX is the only system that does something with the generated data, according to Miriam Strümer from ZKM the SCALEX PDAs deliver information that varies with the history of the visit.

Experiences of museums: Most museums are satisfied or even enthusiastic with their multimedia guide, although they encounter problems with them. They see these problems as start up problems because of the new technologies. Table 2.3 gives an overall result of how museums experience the system.

2.2 Similar projects

This section addresses the challenges in designing a product that acts as a personal and context-aware multimedia tour during museum visits. The scope in this section is on the design project and not on the product.

Other attempts to design a product that can act as a personal context-aware information system have taken place in the past; some of them are available on market, but they are not yet very successful. We suspect that in most of those projects some components receive a lot more attention than others, being perceived as "the most important" by the project members. For example a project can focus mostly on new positioning technologies and the members of the project team think the user will find this system amazing and is willing to work with it. Or a project focuses on the user interaction and eventually the technology itself is not advanced enough for the system at that moment in time. At the end, this means the resulting system lacks a proper balance between its components. Bornträger and Cheverst mention in their paper that research about mobile guides is split into 2 main categories, namely technical solutions and social and usability aspects [8]. To overcome the fact that the system is unbalanced one should see the system as one integrated product and focused on all stakeholders that will have to work with it. This also means looking ahead to the future, because the system will need maintenance and updates. When the collection changes or when there is a new exhibition those objects and spaces have to be easily implemented in the system. A museum is not willing to pay for a system every two or three years.

To be able to address the problems with this kind of projects and to learn from other similar projects research is done on two of such projects, namely GUIDE Lancaster and SCALEX. Bornträger and Cheverst from the GUIDE project in Lancaster [8] give an overview about pitfalls designers of tourist guides might fall in. They divide the pitfalls in human aspects and technical aspects and give a view on their methodology. The reasons for not using the developed guide systems actively in museums after the projects are finished, are not often described in papers. So the only way to find answers is to ask the people who were involved in those projects. Through e-mail the author had contact with DI Jochen Martin and Prof. Karl Stocker from FH JOANNEUM Gesellschaft mbH, who worked on the SCALEX project [2], to ask them what happened with the results of the SCALEX project and if there are museums that use the system.

2.2.1 SCALEX project

Jochen Martin from the SCALEX project emailed that the system is not in use within museums and that the technology is used in other in-house research projects. At the moment of contact (May 2007), they were in contact with two Austrian museums that are interested. Jochen Martin points out some aspects that they found out while developing SCALEX. The most important issues are summarized here:

The technology has to be stable and working 24/7 without maintenance. This involves the client devices, the server and the network connection. The SCALEX project used WLAN and there biggest

problems came from the network connection. They see the solution in having all the content on the devices by using big memory cards and let all the functionality work locally.

The device has to function without the stylus. The interface has to be designed for finger-use.

There should be no buttons on the PDA. The project team of SCALEX found out that the buttons on a PDA are disturbing. They disabled them but say that this was probably not enough; the buttons should not be there at all.

The device has to be specially designed for this purpose. Standard PDA's are not really made for renting them out in museums. Jochen Martin wrote me that visitors can do a lot of harmful things to the device because it is not theirs, they don't care about the device. They drop it, dismount everything they can dismount like remove the battery pack and they will press the reset button.

2.2.2 GUIDE project

The following list summarizes the technical, social and methodological aspects researchers should be aware of when performing user tests according to Bornträger and Cheverst from the GUIDE project in Lancaster [8].

Human aspects

Acquisition of people for the user tests: Asking colleagues is the easiest way to get people but they have a biased view. Therefore they are not qualified as test persons but they can be used to prepare the test and to find flaws in the test setup. Offering money can be helpful in getting test persons and would probably deliver a low rate of experts. But paid participants are not equal to the future possible users from the target group. Students are also not reprehensive for the target group because they have a typical age and education profile.

Consuming the users time: The test supervisor can be recognized as a time-consuming agent; during the field trails of the GUIDE project the most heard excuse was that people don't have time. The GUIDE team suggests to prepare good reasons why people should participate in the test and to tell test persons that they can go whenever they like to. Also, test persons can have the feeling that they are unable to satisfy to the supervisors expectations. The GUIDE team suggests avoiding a lab ambiance and embedding the test into the visit. This will also give more authentic results.

Hawthorn effect: People behave different if they know they are evaluated.

Technical aspects

Stability: The system with all used technologies has to be stable, because otherwise it will confuse the user.

GPS as positioning technology: GPS needs a warm up period; it takes a while till its getting positions. This can take 20 minutes if all ephemeris need to be orbited from the satellites. Users can think that

something is broken if no new position is obtained for some seconds, because the 'cursor' stops moving.

Usage of headphones: All GUIDE test persons rejected the use of a headphone and preferred to use the speakers. Reasons for that were that it looks strange, that people do not want to be recognized as tourists and that the users did not know when exactly audio was pushed by the guide.

Methodology aspects

Flexibility during the test: Design decisions made before the user tests might not conform to the test persons wishes. Therefore, it is important to keep flexible at all times so that the test setup can be changed during user test based on new knowledge.

Designing the interview: Users might come with more ideas if the interviewer gives some small examples.

2.2.3 Challenges

The sections 2.2.1 and 2.2.2 has brought some challenges to light, which have been encountered by project teams on similar projects.

Challenges encountered in similar projects:

- Assuring that the technology is stable and works 24/7 without maintenance;
- Design an interface that can be operated by finger;
- Design a device without visible hardware buttons;
- Design a device specifically for this purpose, protected against the harmful things users can do to it;
- Coping with the flaws in positioning technologies when designing a guide based on one;
- Giving users a choice in how they want to consume audio fragments;
- The acquisition of people for the user tests who are representative of the target group;
- Prevent people from changing their behavior when participating in a test;
- Keeping the system flexible, to allow for changes during the user test phase;
- Get as much information out of users as possible.

These challenges answer research question 3: "What are the challenges in delivering personalized information to visitors?" from the viewpoint of the designers. When designing a product that acts as a personal and context-aware multimedia tour one must be aware of these challenges to be able to tackle them.

During the design process of the Virtual Museum, all aspects will be considered as important, although the multimedia guide is the part that is designed more in detail in this report. For the parts that are not designed further, guidelines and specifications are given to ensure that these parts fit in the Virtual Museum. Furthermore, the technical and human aspects are not split up into different project teams but brought together to design one integrated product.

2.3 Conclusion

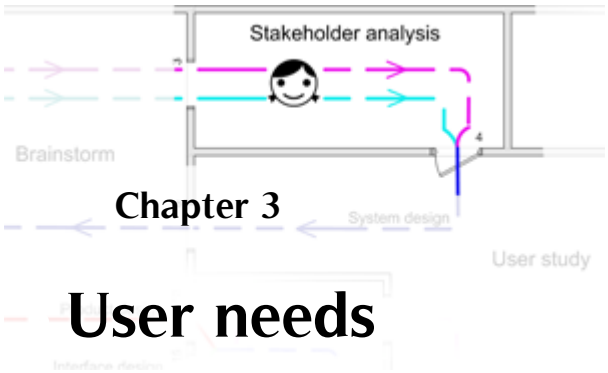
Research answered the first three research questions and also brought some interesting challenges to light from the viewpoint of designers of multimedia guide system.

A multimedia guide system, designed to enhance museum visits, generally provides the user with a PDA or tablet PC. Some use GPS, infrared, RFID or WLAN technologies to create location-awareness or to request object information. Different media types are used by the guides to communicate information.

Multimedia guides can disclose large amounts of information, tell the stories behind the objects, make comparisons between objects, provide that visitors stay longer in the museum and support visitor profiling. But multimedia guides can also have problems, like PDAs that crash or fail to start up. Furthermore, museums need to have a desk with trained staff members to give the user explanations and ensure publicity and marketing, but they do not want to need extra know-how to preserve the system.

The biggest challenges for museums are: to get visitor to use, and to pay for, the multimedia guide; to get the museum staff to actively promote the guide; to keep the system up to data and keep the guides fully charged; to provide the right amount of POIs and to provide the user with an interface he understand immediately. For designers of multimedia guides the biggest challenges are: assuring that the technology is stable and works 24/7 without maintenance; coping with the flaws in positioning technologies; keeping the system flexible, to allow for changes during the user test phase; the acquisition of people for the user tests who are representative of the target group and preventing people from changing their behavior when participating in a test.

Extensive technical descriptions of the systems treated in the market research can be found in Appendix B.



Chapter 3

User needs

The previous chapter answered the first three research questions. This chapter will answer and report on the fourth and last question: What are the needs and opportunities of different stakeholders of TTH? The answer on this question will result in requirements for the system that is to be designed.

The system that is to be developed has to fit the needs of his users. The user needs and their impact on the requirements of the Virtual Museum are formulated in this chapter. This is done by means of related research and interviews. Eventually the user needs of the visitors, the museum and the city are translated into user requirements, which are introduced in chapter 4: Requirements. The most important ones are also listed in section 3.3.

The most important stakeholders are the museum visitors, the museum with his staff members and the city. The stakeholder will use the product directly or indirectly. The museum visitors will directly interact with the personalized context-aware multimedia tour when they visit the museum. The museum itself should profit from this new system, as well as the city. The main interest of the city of Hengelo in the museum is that it attracts tourists to the city, and helps to conserve its history

3.1 Visitor needs

To be able to know how to attract visitors to (re)visit the museum we need to know what drives them in the first place and who they are. In the book "The museum experience" Falk and Dierking [9] give an overview on the research conducted to answer why people go to museums. When selecting a leisure-time activity, people in general look for an activity that involves a combination of the following six criteria:

1. Being with people, or social interaction;
2. Doing something worthwhile;
3. Feeling comfortable and at ease in one's surroundings;
4. Having a challenge of new experiences;
5. Having an opportunity to learn;
6. Participate actively

Frequent museum-goers (three or more visits a year) highly value all six of the criteria and perceive that museum are places that could satisfy all six. The three most important attributes to this group are opportunities to learn, challenge of new experiences, and doing something worthwhile.

People who do not visit museums find being with people, participating actively, and feeling at ease in their surroundings the most important criteria and believe that, for the most part, these criteria will not to be found in a museum. They prefer to spend out-of-home leisure time with shopping, picnicking, watching or participating in sports and family-centered activities. Learning, challenges and worthwhileness are ranked as unimportant by this group.

Occasional visitors (once or twice per year) share more characteristics with non museum-goers than with frequent museum-goers and believe that museums facilitate some of there criteria. They prefer family-centered activities, participating in outdoor sports, making music, applying arts, going to the movies or amusement parks and sightseeing. Occasional visitors visit museum mostly during special exhibitions, family events and when entertaining an out-of-town visitor [9].

To attract more visitors to the museum it might be interesting for a museum to focus more on the needs of people who do not visit museums. Outdoor participating activities are the typical activities that interest this group; museums might facilitate to combine such an activity with a museum visit to expand their target group.

To be able to identify the visitors' needs it is important to know what people want when they visit a museum. Researchers of "The Australian Museum Audience Research Centre" tried to answer this question by analyzing a range of evaluation studies conducted at the Australian Museum (a national museum about nature and culture) [10]. The list with user wants, drawn up by the Australian researchers, can be found in Appendix C.1. These wants have to be taken into account when designing a personal and context-aware information system.

In order to get insight in wants, directly in regarding with a visit to the Twents Techniekmuseum HEIM, the author conducted interviews with a 54 year old carpenter (male), a 50 year old clerk (female) and a 25 year old student (male) who visit museums on average three times a year. From these interviews some user wants resulted, which are listed below, that complement the list of wants from the Australian Researchers.

Users:

- do not want to stand at one object for a long time: the presented information must not be too extensive;
- want to be able to choose whether to read or to listen to the presented information;
- want general descriptions about the objects.

A full list with questions related to museum objects can be found in Appendix C.2. These questions are more specific about the objects in TTH and will be very handy when designing content and to decide in which categories the information has to be ordered. In section 3.3 the user needs found by the Australian Museum Audience Research Centre and the user needs extracted from the interviews are translated into requirements for the system that is to be designed.

3.2 Museum Needs

For museums in general, visitors are their right to exist. To keep those visitors satisfied it is important that the museum tries to fill the visitors' needs as good as possible.

The museum needs to:

- attract visitors to (re)visit the museum;
- conserve cultural heritage and make it available to the public;
- expand their preservation of cultural heritage.

According to TTH visitors can be day trippers, families, students, citizens, school classes, entrepreneurs, etc. The following list of wishes is set up, together with TTH and SIS. To serve all these visitors best and in order to be able to attract them to a (re)visit, **the TTH wants to:**

- involve the visitors not only during, but also before and after a visit;
- cater exactly that information about the collection that the visitor would like to receive;
- gain insight into the experience visitors have in the museum;
- collect information from the visitors;
- set up special school programs;
- test and improve theories about museum visitors and the behavior of museum visitors;
- test and improve theories about the composition and placement of exhibitions and objects;
- present multi-language information that is easy to update;
- set up cooperations with knowledge institutes;
- create a meeting place for entrepreneurs.

The museum needs are used to write a scenario about the conservator of the museum. This scenario can be found in Appendix D and is written in Dutch. This scenario is used to communicate the needs of a conservator with the TTH. That pointed out that the following to aspects are specially of interest to an museum's conservator.

The conservator wants:

- to know how popular the different museum objects are;
- to know if the placing of the object in the museum can be improved.

In chapter 4 the museum's needs and wants are translated into requirements for the system that is to be designed. The needs "set-up cooperations with knowledge institutes" and "create a meeting place for entrepreneurs" do not impact the Museum System, and are therefore not listed as requirements.

3.3 Conclusion

All user needs, listed above, have impact on the requirements of the different parts of the system that will be developed. The most important ones are listed here and these ones will also be included in the list of requirements in Chapter 4. All things the product should and could as result of the user needs that are indicated in this chapter can be viewed in AppendixC.3 and will be used during the design process. A part of the user needs result directly in functions of the system, these user requirements will be mentioned when defining the parts of the system and their functionality in chapter 7: System design.

From the point of view of the user, the designed product **may not:**

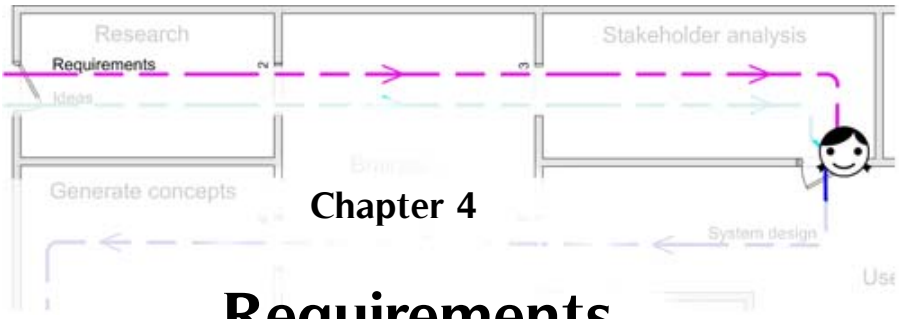
- stand in the way of an active hands-on experience;
- overload the visitor with information, the visitor has to be able to choose between a standard version and an extended one;
- restrict the user in using all his senses.

From the point of view of the user, the designed product **must:**

- be well-maintained and working at all times;
- be designed in such way that the user is allowed to touch every part of the Information Assistant without doing it any harm;
- give a child the opportunity to experiment with the device;
- have a weight and size that is suitable for a child. As guideline the first Sony Walkman (TPS-L2) is used, this weights approximately 400 gram and its dimensions are 135 x 90 x 30 [11];
- point the users to the object they stand for, to ensure that interaction takes place between the visitors and the object, and not only between the Information Assistant and the visitors;
- be able to be personalized, but also to be able to be used directly.

From the point of view of the museum, the designed product **must:**

- give insight in the flow of visitors through the museum;
- give insight in how often an object is viewed and bookmarked.



Chapter 4

Requirements

The objectives and requirements of the graduation assignment, which are mentioned in the introduction, the background research and the user needs result in requirements and boundary conditions for the product that is to be designed. In the chapters Background and User needs the scope was on problems, challenges and wants of the users, in this chapter they are translated into requirements that can be measured. So that at the end the designed product can be evaluated by means of these requirements. And that future similar project like this one can use these requirements for their product that has to be designed.

Boundary condition 4 is from the master thesis of Paul Uithol [1] on indoor positioning, which will provide the product to enable location-awareness.

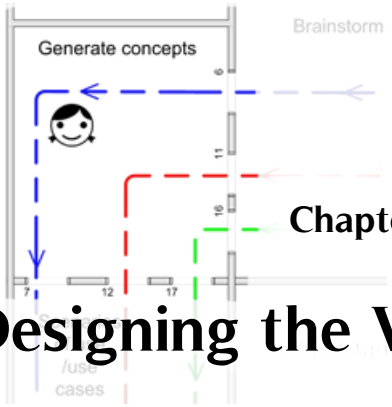
	Boundary conditions	Source
1	The system has to use modern multimedia and internet technologies.	Title of the graduation assignment.
2	The presented information has to be linked to the location of the user.	Section 1.2
3	The information has to be adjustable to personal preferences.	Section 1.2
4	The system has to contain a mobile platform, to run programming code, that users carry with them during a visit.	Report on indoor positioning[1].
5	The system may not restrict the user in using all his senses.	Section 3.3
6	The device must have a weight and size that is suitable for a child; As guideline the first Sony Walkman (TPS-L2) is used, this weights approximately 400 gram and its dimensions are 135 x 90 x 30 [2].	Section 3.3
7	The device should be controllable by finger touch rather than stylus	Section 2.3
8	The system has to be information pull based, so that the user is in control of the information he consumes.	Section 3.1
9	The visitor has to be able to bookmark objects and browse for more information on the website.	Section 1.2

	Requirements	Source
	General requirements	
1	The technology has to be stable and working 24/7 without maintenance.	Section 2.2
2	The device must be able to replace common audioguides, the threshold (unwillingness to use) may not be higher.	Section 2.3
3	People shouldn't be bothered by other users working with the system.	Section 2.1.1
4	Novice users should be able to work self-confident with the product within 5 minutes.	Section 2.3
5	The user should never be exposed to script code.	Section 2.3
6	The attention between device, exhibition and surroundings has to be well balanced.	Section 2.1
7	The system should be an aid for the visitor to find information he prefers.	Section 3.1
8	The museum visit has to remain a social experience, as it is in the current situation.	Section 3.1
9	The product shouldn't confuse the user; i.e.don't show buttons or elements that are not in use.	Section 2.2
	Look and feel	
10	The system and its components have to be adaptable to a specific organization and audience.	Section 1.2
11	The system and its components have to express one identity.	Section 1.2
	Physical properties of the device	
12	The device should be independent from a specific type or brand of PDA.	Section 2.1.7
13	It has to be prevented that the battery is low all of the sudden, especially when the user is not near to a place to renew the battery.	Section 2.1.1
14	Users have to find it comfortable to carry and using the device around during a museum visit.	Section 2.1.1
15	The content on the screen has to be readable in the different lighting conditions wherein it will be used, like direct sunlight.	Section 2.1.7
16	Users have to be prevented from dismounting the device or pressing the reset button.	Section 2.2
17	The device has to be shock resistant or be prevented from dropping.	Section 2.2
18	The device has to be secured against theft.	Section 2.3
	Interaction	
19	The user should be able to adjust the volume in one action and this volume control must be easy to find.	Section 2.1
20	Users who would otherwise use an audioguide must find the system easy to use.	Section 2.3
21	The device may not stand in the way of a hands-on experience.	Section 3.3

	Interface	
22	The interface has to be intuitive; users should be able to use the device without reading the instructions.	Section 2.3
23	The interface should use navigational elements that will be recognized by the users.	Section 2.1
24	The method of navigation has to be consistent on every level in the interface.	Section 2.1
	Control	
25	The training that is needed to teach museum employees to work with the system must not exceed a 2 hours training session.	Section 2.3
26	Museum employees with minimal technical knowledge have to be able to edit the content as quickly as they would edit a Microsoft Word file.	Section 2.3
27	The generated data should be presented to the museum employees in a way that gives them insight in visitor behavior.	Section 3.2
28	The museum employees must find it easy to update the content on the devices.	Section 2.3
29	The museum employees must find it easy to charge the devices.	Section 2.3
	HEIM specific requirements	
30	All products must have a HEIM look and feel	Section 1.2
31	Citizens of Hengelo need to get involved through a platform for contributions by the public.	Section 1.2
32	The system has to attract people to (re)visit the museum and share their experiences with the museum and other visitors.	Section 3.2

Part 2: Design

Part 2 covers the design phase. Chapter 5 describes the concept of the Virtual Museum and the key characteristics where concepts were designed for. This concept was presented to TTH, SIS and the city of Hengelo by means of a written scenario and visuals in a presentation. Remarks were used to improve the concept until it satisfied TTH and SIS. The scenarios are used in Chapter 6: Scenarios of use/use case, to communicate the concept to the software engineers. The concept of the Virtual Museum is further developed in Chapter 7: System design. Prototypes of the Information Assistant are tested in different stage of the project; why and how this is done is described in Chapter 8. Chapter 9 discusses the Graphical User Interface and all of its components.



Chapter 5

Designing the Virtual Museum

The purpose of this chapter is to design a concept for the Virtual Museum that combines modern multimedia and internet technologies to enhance museum visits and visitor involvement. Section 5.1 describes how a multimedia guide can enhance museum visits, and Section 5.2 describes how to enhance visitor involvement. As stated in section 1.2 the Virtual Museum of TTH should at least contain, connect and provide a personalized context-aware multimedia tour in the museum, and 'bookmarking' in the museum for review at home. In Section 5.3 key characteristics are generated to distinguish our Virtual Museum from the systems investigated in the market research (section 2.1). The key characteristics are then used to generate concepts. In section 5.4 this results in one concept for the Virtual Museum.

5.1 How to enhance the visit

Although all four research questions from section 1.3 have been answered in Chapter 2 and 3, it has not yet been established how modern multimedia and internet technologies can be combined to enhance museum visits and visitor involvement. In the Market Research, visitor experiences were evaluated to determine if a multimedia tour is able to enhance the museum visit. These visitor experiences (which can be found in Appendix B) point out that multimedia guides are capable of enhancing the visit.

According to the Steven Kolsteren, head of education of the Groninger Museum, visitors were very enthusiastic and specially liked the ability to choose which information to view. According to Drs. Herman Tibosch, head of education of the Kröller-Müller Museum (KMM) a study conducted by KMM pointed out that 87% of the visitors that used the guide was of opinion that the device improved their museum experience. Gillian Wilson from Tate Modern writes that almost all users thought Tate Modern's Highlight tour had improved their visit and most users thought they had stayed longer in the gallery than they would have done without the guide [13].

The following lists with aspects that enables multimedia guides to enhance the experience, has been distilled of the visitor experiences in the Market Research (Appendix B).

A multimedia guide should:

- allow users to choose the information they access;
- support social interaction among visitors;
- support talking and discussing among visitors;
- have an interface designed according to general interface guidelines;
- tell the user what to expect, so users can experience the tour is a coherent way;
- react quickly (within one second) to user commands;
- give the user the feeling that it adds something to the museum experience.

The content should:

- add information, and not just present it in a different way;
- provide the user with information he finds interesting;
- provide texts which users find satisfying;
- contain audio fragment users find nice to listen to.

And a multimedia guide should **not**:

- freeze if a user clicks on buttons when the application is loading;
- freeze in general;
- show the user error messages and script code;
- play audio fragments the user did not asked for without a warning;
- only use the device's speaker for the audio output, as this can cause nuisance to other visitors;
- overload the visitor with multimedia information;
- push more information towards the user then he wants to receive;
- provide the user with content that can not be seen properly because of environmental influences like sunlight;
- have visible (hardware) buttons if they are not in use, because they confuse the user;
- lead to the fact that users have to walk back to the counter because for example the guide's battery is empty.

These aspects, were used when designing the product that can act as a personalized context-aware multimedia tour in the museum (section 5.3.4).

5.2 Enhance visitor involvement

The conducted research has not yet pointed out how to enhance visitor involvement. According to Silvia Filippini Fantoni et al [14], supporting a so called 'virtual circle' can strengthen the relationship between visitors and museums. A Virtual Circle, as explained by Filippini Fantoni et al, supports the visitor before, during and after the visit and it supports the transition between a person's pre visit (before), visit (during) and post visit (after). However, because the model ignores the transition between one person's post and pre visit, the metaphor of a Virtual String is more fitting (figure 5.1 a).

Filippini Fantoni et al illustrate the process that is used by the J.P. Getty Museum in California as an overall connection between the three phases. In the Virtual String of the J.P. Getty Museum, visitors can email their bookmarks to friends. This connects the post visit from one visitor to the pre-visit of another visitor. Therefore, a better name for the model used at the J.P Getty Museum would be a Virtual String-chain (figure 5.1 c). Supporting the connection between a visitor's post visit and pre-visit in order to stimulate a revisit, would be a true fulfillment on the idea of the Virtual Circle (figure 5.1 b). A Virtual Circle, where the pre-visit, the visit and the post visit from one person are linked to each other, can be converted to a Virtual Circle-chain if for example the post visit from one person is linked to another ones pre-visit. This Virtual Circle-chain (figure 5.1 d) can support the relationship between visitors and the museum optimally, because it can stimulate people to revisit the museum and it can be the basis of a community built around the museum's website.

A visualization of a Virtual String, Virtual String-chain, Virtual Circle and Virtual Circle-chain is given in figure 5.1 below.

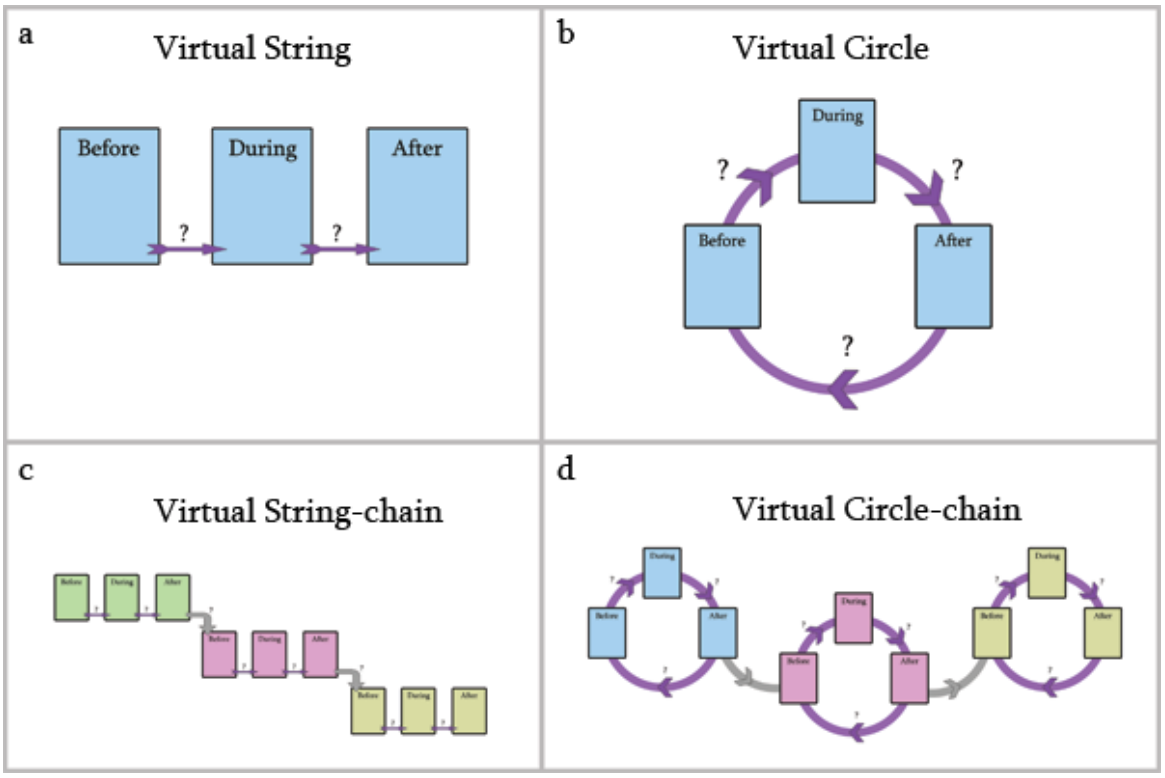


Figure 5.1: *The different 'Virtual Circle' models.*

So, to enhance the involvement of visitors in the museum the model of the Virtual Circle is an excellent tool, because it stimulates a revisit and creates a community around the museum. The Virtual Circle-chain is the most optimum state that can be reached by starting with the creation of Virtual Strings after which a Virtual String-chain or Circle can be created to eventually create a network of Virtual Circle-chains.

5.3 Generate Concepts

To distinguish the product that is to be designed from the existing products (as investigated in the market research, section 2.1) the following key characteristics have been set up. This has been done together with SIS and Paul Uithol, who worked on the positioning technologies. Siteseeing Internet Services (SIS) can use these key characteristics in the future as unique selling points (USP) of the Virtual Museum.

The key characteristics are:

1. **Indoor and outdoor**: An information assistant for both indoor and outdoor use.

All multimedia guides investigated in the Market Research work either indoors or outdoors, but not in both. A guide that works indoors and outdoors will distinguishes itself from the other guides. The TTH is surrounded by the Tuindorp district, home to many old factories and workers homes. Most of the TTH stories take place in the factories and homes of this district. With a multimedia guide that works indoors and outdoors the museum can be extended to the Tuindorp district.

2. **Pull-based, personal and context-aware**: A combination of a pull-based information system, personal preferences and the actual location of the user.

As stated in section 1.2, the product should act as a personal context-aware information system to visitors during the museum visit. The product has to be information pull based, so the user is in control of the information he consumes (boundary condition 8). The information has to be adjustable to personal preferences (boundary condition 3) and the presented information has to be linked to the location of the user (boundary condition 2). And the product should be an aid for the visitor to find information he prefers (requirement 7).

3. **Relive and expand the visit**: The museum visit can be re-lived and expanded on the Virtual Museum website.

Enhancing the museum visit can be done by using a Multimedia Guide but also by visiting a museum's website where visitors can re-live and expand their visit. An optimal solution would be to combine the two, using the Virtual Circle, as introduced in section 5.2, to support the visitor before, during and after the visit and the transition between these phases.

The system has to entice people to (re)visit the museum and share their experiences with the museum and other visitors (requirements 32). The visitor should be able to bookmark objects and browse for more information on the website (boundary condition 9). The Virtual Museum website can facilitate these functionalities.

4. **A complete package**: A complete package consisting of information assistants (devices), a content creation program, a data-analysis program and a website, which are all linked to each other.

The Virtual Museum consists of multiple parts, but it is important to see the Virtual Museum as one integrated product so it will become a complete package with components that are in balance with each other.

5. **User created content**: The visitor can add new information to the assistants and the website through the Virtual Museum.

Citizens of Hengelo need to get involved through a platform for contributions by the public (requirements 31). This platform is a part of the Virtual Museum and also helps to create a Virtual Circle-chain by connecting people personal Virtual Circles because they, for instance, reply on each others stories.

6. **The technology explained**: The inner workings of the positioning systems are explained to the user for a better understanding and thus a better experience of the museum visit.

The TTH is a technological and historical museum where the technology of, for example, steam engines is explained. Therefore it is rather logical to also explain the technology of the multimedia guides.

Based on these six key characteristics concepts are generated. They will be treated one by one, each one resulting in a small conclusion or a summary.

5.3.1 Indoor and outdoor

What factors should be taken into account when designing a guide for both indoor and outdoor use? A difficulty that arises is the difference in context between indoors and outdoors. Towards the user it is important that the interaction with the personal and context-aware product is on all moments consistent. Therefore the transition from indoor to outdoor and the other way around has to be as smoothly as possible. The interaction with the product has to stay the same whether the user stands inside or outside a building. For a smooth transition the threshold that is visualized in figure 5.2 has to be eliminated.

Differences and similarities between indoor and outdoor

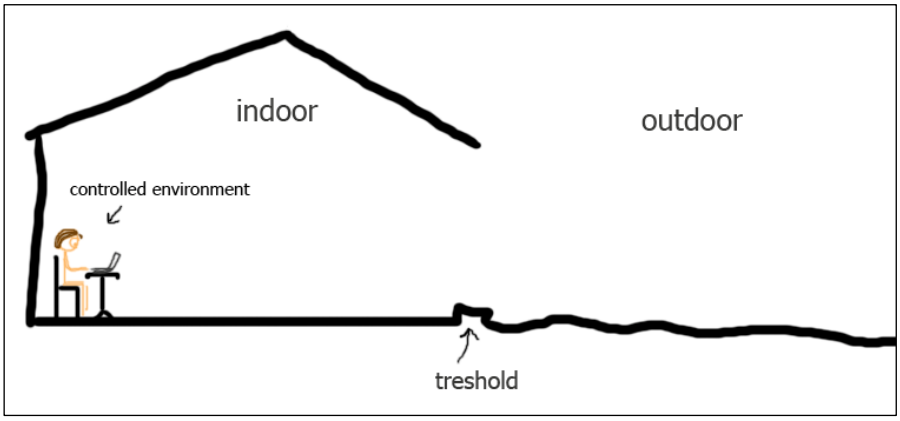


Figure 5.2: *Visualizing the threshold between an indoor and outdoor environment.*

Differences:

	Indoor	Outdoor
Controlled by:	One authority	Many authorities
History of:	Objects	Objects and locations
POI density:	High	Low
Object size:	Small	Large
A location can posses:	multiple objects.	different objects, on different points in time
Data transfer options:	WLAN	GPRS/UMTS

Similarities:

- Information linked to coordinates (physical locations).
- Objects linked to coordinates.
- Information for different points in time available.
- Indoor and outdoor objects both have a history.

Both, indoor and outdoor objects, have stories about them that change over time. An outdoor location has a past, a present and a future in which things change: buildings can arise and disappear and the function of a building can change. The same goes for objects indoors. Additionally, these can also represent for instance a technology, or depict a certain situation.

Conclusion

In the multimedia guide indoor and outdoor environments can be treated practically the same, because it is mainly the scale that changes (figure 5.3). Outdoors the objects are larger and the POI density is lower compared to indoor objects. Both have objects and information that are linked to coordinates and that changes through time. For both data transfer options are available to send users the information and it are both controlled environments although this gets more complicated outdoors with many authorities.

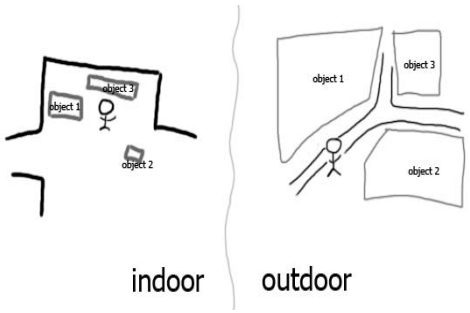


***Figure 5.3**: The difference in scale between an indoor and outdoor environment.*

The Tuindorp district is more related to the museum (TTH) than the rest of the city, the density of POIs is therefore larger in the district. The importance of an accurate position is higher when objects are smaller and the density of POI is larger, figure 5.4 visualizes this relation. For the outdoor areas the positioning technology GPS is sufficient, because most objects are larger than the inaccuracy of the position given by GPS (5m). This technique can not be used indoors, therefore another position technology has to be used there. Information about this specific problem can be found in the Master Thesis about indoor positioning [12].

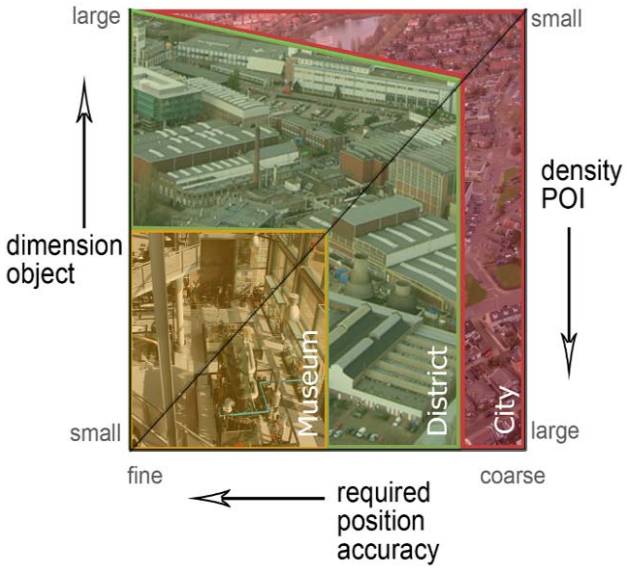


***Figure 5.4:** The relation between the required position accuracy, dimension of the objects and the POI density.*

5.3.2 Pull-based, personal and context-aware

This section covers different ways of creating a pull-based information system and to adapt the information to personal preferences. The location of the user is used to make the product context-aware. When the user's position is known it can also be used for orientation in the museum and to map out routes for the user to certain objects or places.

A pull-based information system

The difference between pull-based and push-based systems is that in the first the user is in control, and in the second the system is in control of the information that is presented. Because we stated it is important that the user is in control of the information he consumes, and that the guide should act as an aid to the user, the system should be pull-based.

Possible ways of requisitioning information were found during the market research:

- Holding the guide before a sensor.
- Holding the guide before a sensor and choose one of the objects that appear on the screen.
- Enter the object's access number.
- Find the desired object on a scrollable timeline in the interface.
- Select the object on a map.
- Touch an info button when standing on the location of interest.

When using some more powerful sensors than the investigated guides use at the moment, it should be possible to point the guide to a sensor instead of holding it before the sensor. The interaction would be more like a TV remote control.

For TTH a map is chosen to select objects to get information, because it makes optimal use of the positioning technologies. The choice for the map is further described in the section Orientation on the next page.

Personal preferences

The visitor should be able to fill out his personal interests, after which the Assistant can filter all irrelevant info. Personal preferences could for instance be filled out on the museum's website, on a terminal in the museum or on the guide itself.

The location of the user

Determining the position of the user is part of a separate graduation assignment at SIS. For the purpose of this assignment knowledge of the position of the user is a given. But the accuracy of this given position is no certainty. The accuracy can be up to 5m and no viewing direction of the user will be obtained. Because the determination of the position of the user is outside of the scope of this thesis it is risky to rely on. Therefore the location is used as the primary means for the user to access information, but not the sole means; backup means will be available.

Information on the indoor positioning system used by the Virtual Museum can be found in the Master thesis of Paul Uithol [12].

Knowledge about the user's location can be used to support the user by:

- connecting a family or group of visitors so they can look up each other's position, especially useful if children are lost;
- providing a personalized tour through the museum based on the personal preferences and location of a user;
- guiding the user to a certain object or room.

For the museum, the knowledge about the locations of the users can be used to get insight into:

- the flow of visitors through the museum;
- how often an object is viewed and bookmarked;
- how and if the flow of visitors through the museum can be improved.

Besides the visitors and the museum, more parties can be interested in information form the indoor positioning system. For example, the fire brigade to see if there are people in the building and where they are.

A map-based multimedia guide

There are multiple ways for the user to obtain information about the specific object the user stands for as listed in the section above (A pull-based information system). The knowledge of the user's location can be helpful in obtaining information about the objects in the user's vicinity. The guide could display information about the object the user stands close, sum up the objects in the user's surrounding, show pictures of the object nearby or show him a map of the area with the objects in his vicinity. The chance that the guide pick the wrong object is large because the inaccuracy of the user's position can be up to 5m, and most museum object are smaller. The same counts for listing objects or showing pictures of objects. With small objects and a high POI density there can be more objects in the vicinity of the calculated position of the user than there fit on the screen. The only feasible option that makes use of the user's position is using a map. A big advantage of a map is that it circumvents the problem that the location can be inaccurate. The map can show the user an area of the museum on which the user's location is marked. The user can then click on the object he actually stand for, to receive information. A disadvantage of a map is that the user has to be able to orientate himself on the map or the map should orientate itself with its user.

Orientation

The knowledge of the user's location can be used by the user to orientate himself in the museum, but first he must be able to orient himself on the map that is shown by the Assistant. Therefore the user must be able to relate his surroundings to information on his location, given by the Assistant. This can be accomplished when the user knows what the north is on both, or know for at least two object on the Assistant their actual position in the user's surrounding. Some people might always know how to face the North but this does not count for every person, especially not for women who find there way by focusing on concrete objects instead of wind directions according to Allan and Barbara Pease [15]. The following ideas can be helpful for orientation:

1. Show where the North is in the user surrounding for example by writing it on the wall.
2. Rotate an electronic map with the user's movements.
3. Provide the user with a compass to find the North.
4. Show landmarks on the electronic map and in the users surrounding so he can orientate himself based on these landmarks.

An advantage of **idea 1** is that it is an easy solution but a disadvantages is that it asks for an adjustment on the physical museum instead of just the Virtual Museum.

Idea number 2, rotate the electronic map, would ideally work like a TomTom navigation system, rotate the map with the drive direction. A big difficulty here is that a human can rotate on his axes and a car (mostly) can not. The drive direction of a car can be calculated based on the moving direction but with the same measurement techniques no axes rotations can be measured. And because the viewing direction of the user will not be measured there are no parameter available to calculate a map rotation.

An analog or digital compass could be used for **idea 3.** An analog compass could be placed on top of the guide helping to find the North. When the map, shown by the Assistant, is always facing north the user just has see to the fact that the compass arrow is facing upwards to map the electronic map with his surrounding. A digital compass could be integrated with the guide so that the map can rotate based on the input of the digital compass. It will be probably best if the map would only rotate in quarters, because otherwise the map will constantly be in movement, making it hard to click on an object to receive information.

Idea number 4 uses landmarks, some large museum objects or doors could be used as landmarks to help the user orientate. A small test has been conducted to see if people can orientate themselves based on pictures of the objects in their surroundings, information on this test can be found in section 9.5.3.

Idea number 4, showing landmarks on the electronic map and in the users surrounding so he can orientate himself based on these landmarks, and idea number 1, show the where the North is by writing it on a wall are the only feasible solution in the case of TTH. It has been tried to equip the guide with a digital or analog compass (idea 3), but it is difficult to use properly because all the steel, magnets and electro motors in TTH interrupt the measurements. Idea number 2 could work on a larger area, for example outdoors, where people walk more in one direction. In that case the direction can be obtained of a string of user positions so that the map can be rotate as it works in car navigation systems. But in a small museum people make little movements in multiple directions, making it hard to obtain the direction an turn the map in the right direction. For TTH idea number 4 is chosen because, in contrast to idea 1, it does not require any adjustment on the physical museum.

Additionally, in order to help people orientate in the museum, objects and rooms that were already visited can be visualized. When users know from which room they came or which objects they visited, they can orientate them based on that knowledge. Zooming in and out on the map to see their

location and the room they are in can also help to orientate themselves in the museum or in an outdoor area.

Routing

People are used to navigating with paper maps, a electronic map can replace this paper map and can have the advantage of being zoomable [16]. Besides zooming in or out, a route could be plotted on the map to guide the user to a particular object or room. This would be a better option than give the user spoken instructions because the guide has no knowledge about what is right or left from the user's perspective. Plotting the route on the map also relieves the audio channel to be used for object information. The user can freely take another route or wander off so the user stays in control. Therefore plotted routes on the map will be used in this project.

Conclusion

With the multimedia guide the user can access information about objects in his vicinity. This information is adapted to his personal preferences. The user will navigate with the multimedia guide trough space and content by using an electronic map. This map can also be used by the user to orientate himself in the museum or the outdoor area. If needed, a route will be plotted on the map to guide the user to certain objects or rooms.

5.3.3 Relive and expand the visit

After a museum visit, visitors can relive and expand their visit on the museum's website. This can be implemented by providing the ability to review the multimedia information from the museum and by giving the visitor the opportunity to dig deeper into information. Not all information owned by the museum will be suitable to present on the multimedia guide, but it can be presented on the museum's website in order to expand the visit.

To ensure visitors will follow up their visit on the museum's website, there must be some kind of bridge between the visit and the post visit. Aspects that can be used to form this bridge are: the bookmarks made on the multimedia guide; tracing the route taken by the user; listing all visited objects; and, showing photographs taken of the user by the museum (webcams could take pictures when visitors are in the vicinity).

Follow up activities that can be provided on the museum's websites, and activities that can support the transition between a museum visit and a website visit afterwards, are placed in the Virtual Circle in figure 5.5.

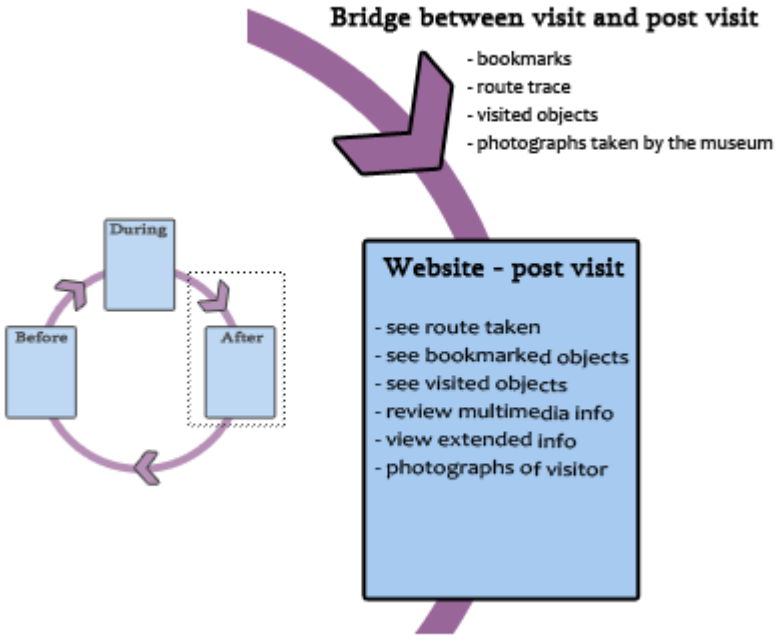


Figure 5.5: *Activities that support the Virtual Circle after a museum visit.*

The museum visit can also be expanded to before the actual visit. On the museum's website visitors could play games and search information on museum objects. To support the transition between the pre-visit and the visit they could book their tickets, fill in their personal preferences, set out a personal museum tour, print a museum's floor plan or even download the multimedia guide onto their own PDA or Smartphone. Figure 5.6 shows how these activities fit into the Virtual Circle.

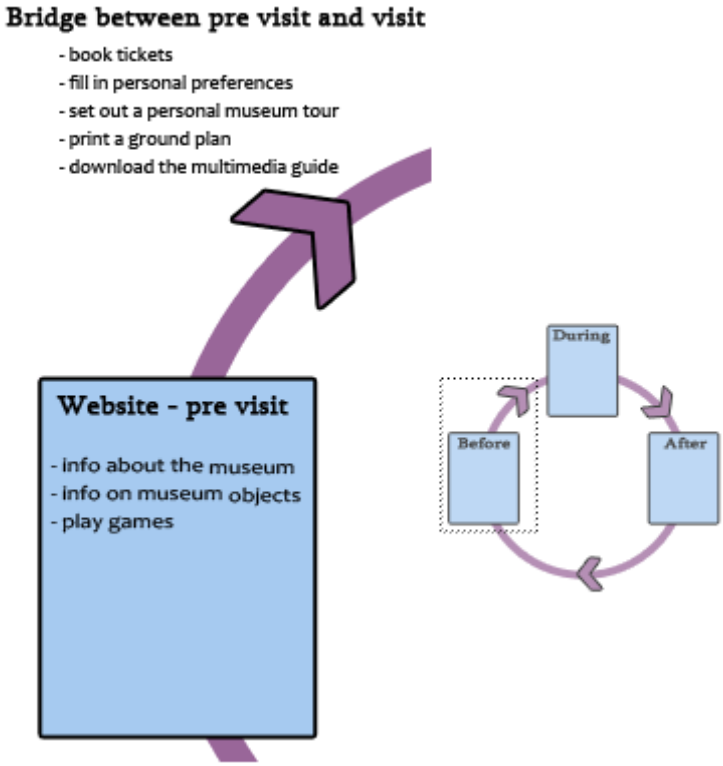


Figure 5.6: *Activities that support the Virtual Circle before a museum visit.*

For a museum, email addresses are of interest to send newsletters that can be adapted to personal preferences. Newsletters can lead to the fact that visitors revisit the museum because for example the museum presents an exhibition that fits the visitor's interests. This is an aspect that can fulfill the circle by facilitating the bridge between the post visit and the pre-visit (figure 5.7). The visitors email address will be asked when the visitor receives a multimedia guide, and must be filled in in order to access the bookmarks on the website. Possible ways to fill in the email address and what is the best way can be read in section 7.3.3.

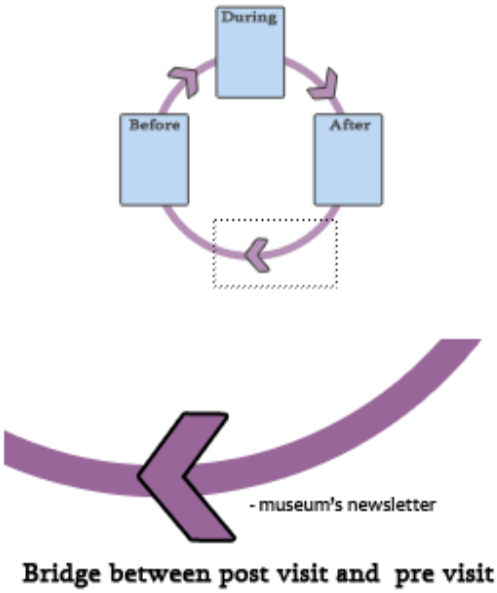


Figure 5.7: *The bridge between the post visit and the pre visit.*

5.3.4 A complete package

The Virtual Museum is a complete package consisting of information Assistants (devices), a content creation program, a data-analysis program and a website, which are all linked to each other.

An initial sketch of this complete package can be seen in figure 5.8. The six pillars of this complete package are the six pillars around which the system is designed. The six pillars are:

- Back-end (content creation program and data analysis program)
- Location based services (information about LBS can be found in the Master Thesis of Paul Uithol [12])
- Information Assistants (multimedia guides)
- Front desk (update and recharge the devices and handing them over to visitors)
- Website
- Content framework (guidelines and specification to make the content)

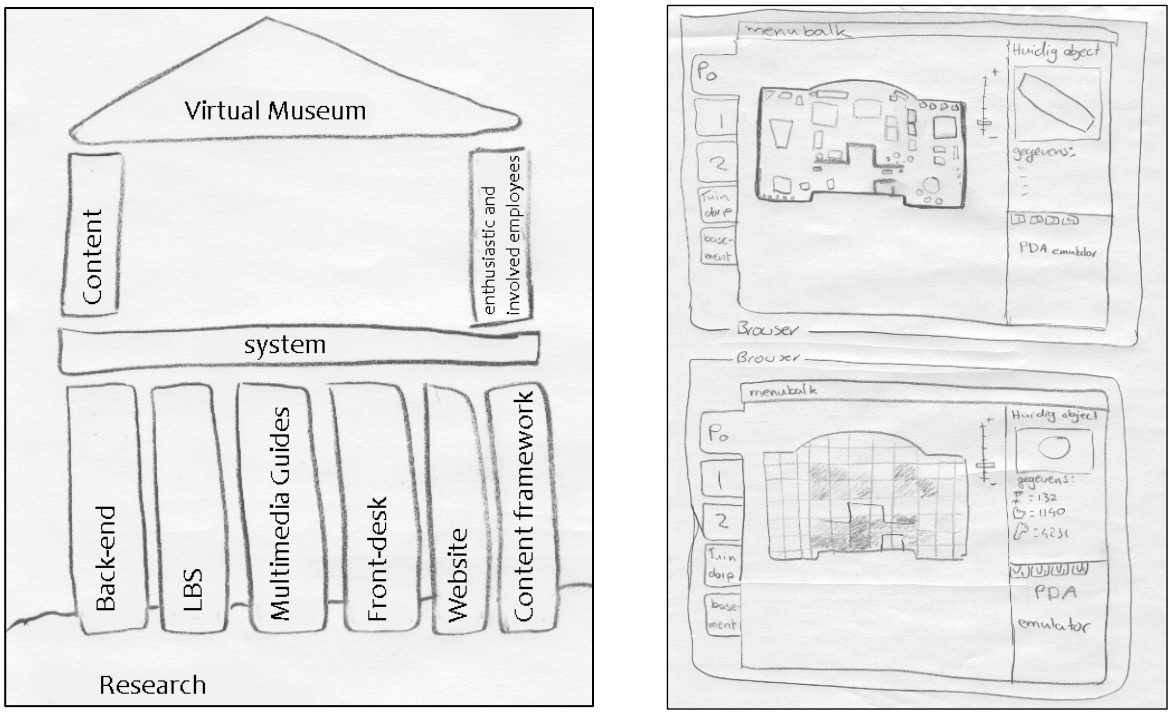


Figure 5.8: *The Virtual Museum with his six pillars, and an idea for the analysis tool.*

Back-end

The purpose of the back-end is to maintain the content and analyze visitor's behavior. The conservator of the museum, and other employees and volunteers, are the only users of the back-end. The content managements system (CMS), to create and edit the content for the Multimedia Guides and the Museum's Website, can be reached through the back-end. With the CMS, the content is held up to date and the cultural heritage is opened up to the public. A data analysis program, part of the Back-end system, generates data that gives insight into the flow of visitors through the museum, and how often

an object is viewed and bookmarked. The generated data will be presented to the museum employees in a way that gives them insight into visitor behavior (requirement 27). A sketch of one way to present the data analysis program is shown in figure 5.8.

The Back-end is not elaborate further since it is outside of the scope of this report. The requirements 25 until 28 impact the Back-end system. The back-end that will be developed for TTH must satisfy at least to those requirements.

Information Assistant

An Information Assistant consists at least of a type of PDA that is type and brand independent (boundary condition 4, requirement 12). The back-end's CMS provides the Information Assistants with information. With the Information Assistant, visitors can view and/or listen to personalized information. The user is in control of the amount and which information he consumes and he can bookmark objects to review them at home. For these five types of actions (view, listen, personalize, control and bookmark) some ideas have been drawn and placed in a morphological diagram (figure 5.9). This morphological diagram is used to organize all current ideas and deduce concepts for the Information Assistant from.

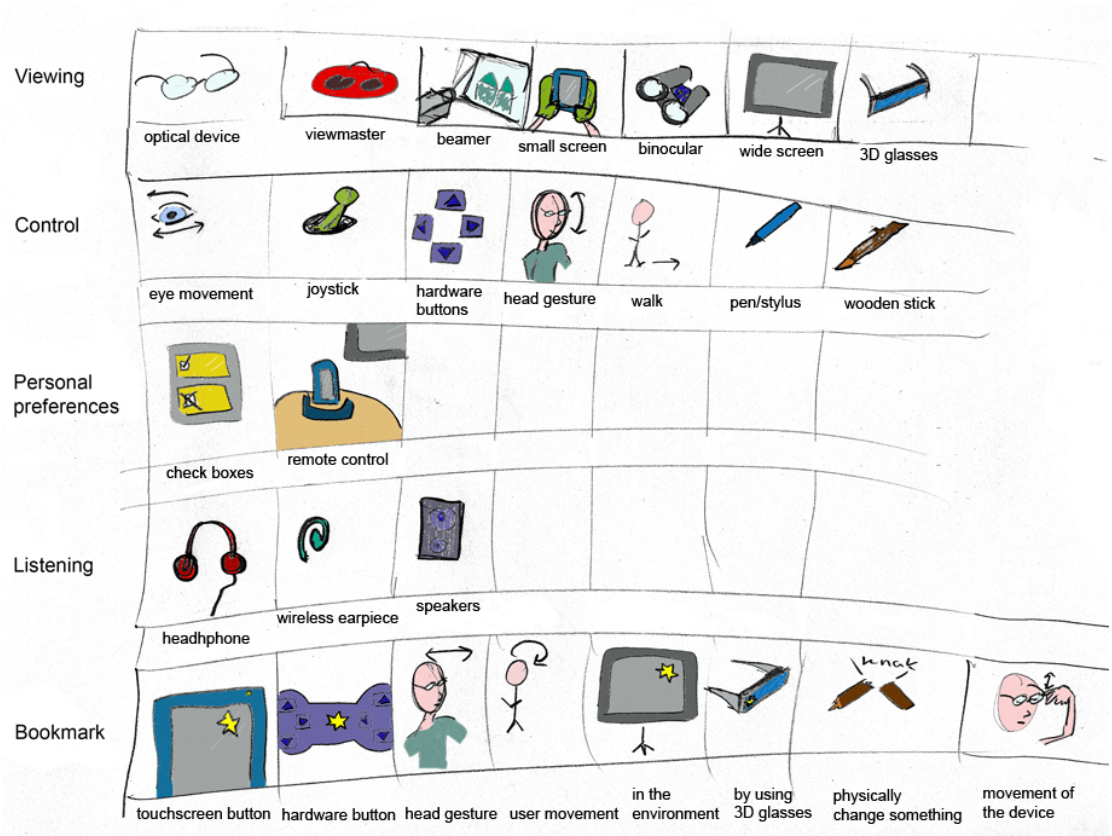


Figure 5.9: *Morphological diagram*

Concepts that make use of elements that have to be placed in the environment can not be used because it would be hard to make it also work outdoors. So terminals, for example, can not be used as a personal and context-aware product. Beside, elderly people may not be so willing to interact with terminals; due to technology fear or technology-fatigue. But the separation of the person from the actual object, while getting the information from the terminal, might also be a reason not to use them. Interacting with a kiosk means that the visitor has to move away of the object he is interested in, while he would prefer to stay focused on the object [17]. When all visitors are provided with a personal device the visitor can stay focused on the object and receive more information on the object.

Because a PDA is already part of the guide as a mobile platform to calculate the users position, it would be a waste not to use it to its full extent. The screen of a PDA could be used to provide the user with information to look at, and a headphone or the PDA speaker could be used to provide the user with audio fragments. Every concept for the Information Assistant has to use a type of PDA. By adding a head-up display the Viewmaster concept of figure 5.10 can be formed. With the Viewmasater concept the museum visitors can view the multimedia information without having to look down at a screen, the information is projected in their surrounding.

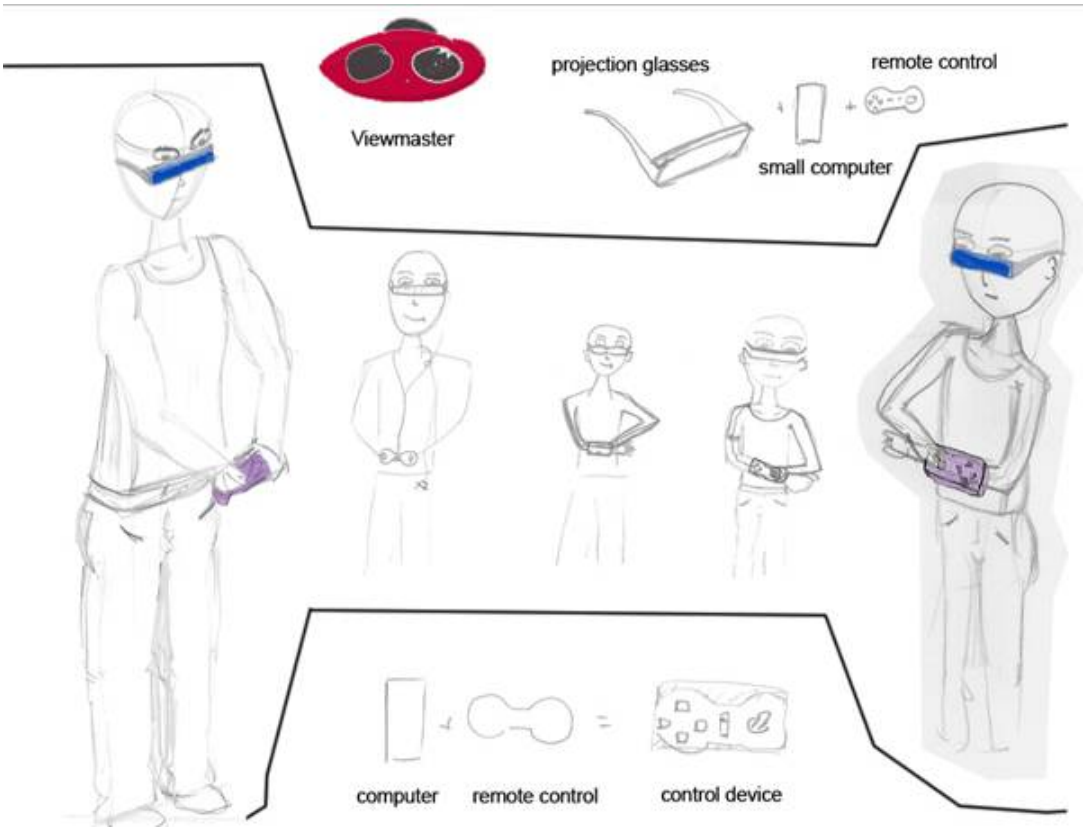


Figure 5.10: *Viewmaster concept*

An advantage of the Viewmaster concept, when comparing it with a PDA with headphones, is that the user does not have to look down at a screen but that he could just look around and sees the multimedia information projected in his surroundings. When there is only a PDA screen to look at for

information the user's attention must be actively divided to overcome that he looks constantly down at the screen. The reasons to drop the Viewmaster concept are mainly practical, a PDA does not have the power to provide a head-up display with multimedia information. Technologies to make the Viewmaster concept to a product that is personal and context-aware and therefore comfortable wearable during a museum visit bit also outdoors, are not yet available.

To keep the concept as simple and affordable as possible only headphones and a PDA will be used as the platform. The viewmaster concept is an extension of this simple concept and could be something for in the nearby future when needed components become available.

Ask a question

In *section 3.1 Visitor needs* a list of user wants was mentioned that have to be taken into account when designing an Information Assistant, this list can be found in Appendix C.1. One of the wants from the list is that users want to be able to ask a question to museum staff. Some kind of multimedia guide can be used to accommodate this. As pointed out in one of the scenarios in Appendix D, there could be a button which can be pressed by the visitor if he has a question. This will send a signal to a member of the museum staff. The staff member knows the position of the visitor and can walk to him to be able to answer the question.

A problem that can occur is that people try the button without having an actual question. Also, children may press this button while playing with the PDA. That means the member of the museum staff that receives the signal will go for a pointless walk. If this happens too often, the museum staff might eventually not respond to the signal at all. A solution could be to use a button that activates the voice recorder of the device. The visitor can leave a message (his question) which is sent to a member of the museum staff. This staff member can send a spoken or typed message back and/or he can decide to walk to the visitor. So when a user is just trying out this button or is playing with it, no serious message is send to the museum staff member, who can decide to ignore it.

Front desk

The front desk is a place in the museum where the Information Assistants are recharged, updated and handed over to the visitors. As already stated in the conclusion of chapter 2: Research, museums need to have a desk with trained staff members when using Multimedia Guides. The front desk must be designed so that the museum employees find it easy to update the content on the devices (requirement 28), and easy to charge the devices (requirement 29).

The front desk is treated in section 7.3.

The website

The website is the part that is used by the museum visitors during the pre- and post-visit to relive and expand the visit. The activities mentioned in *section 5.3.3 Relive and Expand the visit* have to be available through the museum website to optimally support the Virtual Circle.

The website of the Virtual Museum must be seen by the user as an extension of the multimedia guide at the museum. Its components have to express one identity (requirement 11). In the specific case of TTH the components must have a HEIM look and feel that fits the museum (requirement 30). These

requirements can be fulfilled by using the same graphical elements on all parts of the Virtual Museum, but it can also be extended by using similar metaphors. For example, by showing the visitor not only his physical location while in the museum, but also his virtual location on the Virtual museum website. So when the visitor visits the steam engine on the website, the location of this steam engine on the museum's ground plan is visualized on the website. A representation of this idea is given in figure 5.11.

Figure 5.11: *Visualization of a page on the museum's website*

Content framework

The content framework consists of guidelines and specification to create content. This is a separate pillar because the Virtual Museum can not exist without good quality content. The guidelines and specification for the Content framework can be found in section 7.4.

From six pillars to one system

All elements of the Virtual Museum are linked by the internet. To ensure that visitors also see the Virtual Museum as one complete package, metaphors can be used. Specific elements of the Information Assistant can return in the museum and on the website. If an object in the Information Assistant can be bookmarked by clicking on a flag, a real replica of this flag can be placed in the museum at the most popular object and can also be used on the museum's website to show the user the objects he bookmarked during his museum visit. The position of the user is tracked by the Information Assistant in the museum and visualized on the electronic map. When the visitor visits the museum website, his location on the website could also be traced and displayed. Pictures shown on the Information Assistant can also be placed in the museum itself, partly for visitors without an Information Assistant but also to show the link between the information on the guide and the museum itself.

5.3.5 User created content

The visitor can add new information to the assistants and the website using the Virtual Museum. This information can be added online via the museum's website, on a platform for contributions from the public. As stated in section 1.2 the Virtual Museum should allow for integration of such a platform.

A good example of a platform for contribution from the public in the same kind of context is www.geheugenvanoost.nl, a screenshot is displayed in figure 5.12. Mila Ernst from the Amsterdams Historisch Museum says that the platform geheugenvanoost made it easy to involve local residents with their project around the district Amsterdam Oost. She states that the platform brings the project alive and that it contributes to the reputation of the museum. As a reason for its success she names that people are very much involved and interested it the project because it concerned themselves [18].

Figure 5.12: *A screenshot of the webpage www.geheugenvanoost.nl*

All stories from visitors of geheugenvanoost are linked to each other by means of metadata, tags, which are attached to every piece of information.

A similar type of platform could be used by the TTH's Virtual Museum, for example www.geheugenvanhengelo.nl. Trough this platform visitors can add new information to the assistants and the Virtual Museum. Directly adding user created information into the Information Assistants is difficult to achieve because some kind of agent or agency must be in control of the content to filter it from unwanted messages and to perform quality control. Besides that, typing a story directly on a PDA is a burdensome thing to do as experiences during testing the Droombeek guide (Appendix B), due to its small onscreen keyboard.

5.3.6 The technology explained

The inner workings of the positioning systems are explained to the user for a better understanding and experience of the museum visit. Explanations can be given by the guide itself, in the museum as part of its exhibition or by means of small games.

According to Donald Norman, it is fundamental to provide users with a good conceptual model and to make things visible. Users don't need to know how the PDAs and the positioning technologies work exactly, only the relationships between them so they can form a correct mental model. Mental models are the models people have of the persons and things they interact with. These models are formed through experiences, training and instructions [19]. Because the visible structure of the multimedia guides does not give the user clues about how the devices work, it is difficult for users to form a good mental model.

Explanation about how the devices work can be given with the help of games, like the one that is illustrated in figure 5.13. In this game the size and position of the yellow dot is changing, depending on the position of the PDA. If the user wants to know how this works he only needs to confirm and the technique will be explained on the big screen. More games of this kind can be found in Appendix I. These games teach people in an enjoyable way how the system they use works, and provide the user with a conceptual model of the system.

Furthermore, the TTH is a technological and historical museum. New technology is more and more miniaturized: everyone uses it but it is hard to see the inner workings. These games and an exhibition in the museum could show the user the technology in the small boxes that provide for example the determination of the user's location. The big screens (figure 5.13) in the museum that are used to play the games are also available to visitors who choose not to walk with a PDA to access object information.

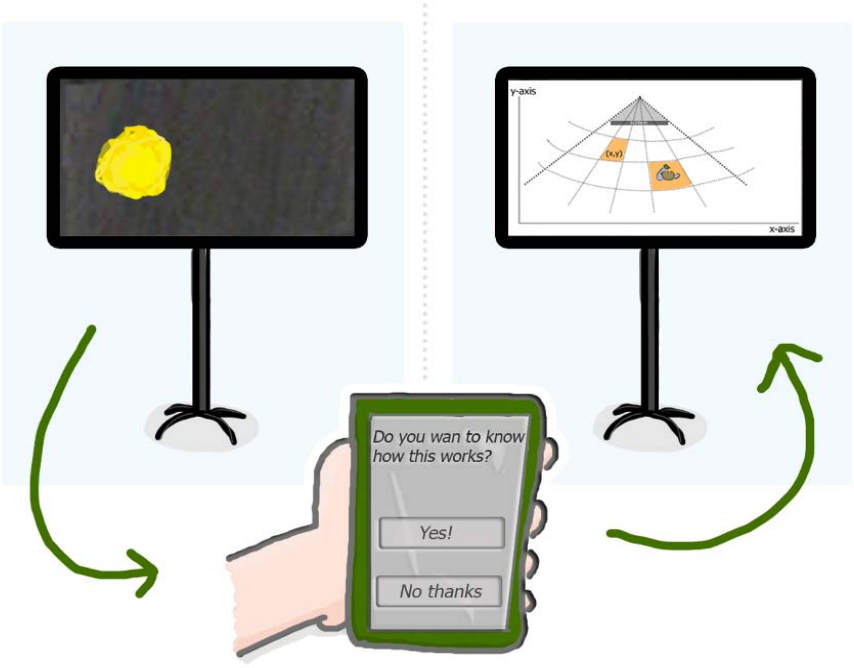


Figure 5.13: *A game designed to experience and explain how the indoor positioning system works.*

5.4 The Virtual Museum concept

When all concepts, from the previous sections of this chapter are combined, one concept for the Virtual Museum emerges. The Virtual Museum is a complete package consisting of the six pillars mentioned in *section 5.3.4 A complete package*. This concept was presented to TTH, SIS and the city of Hengelo by means of written scenarios and visuals in a presentation. Remarks were used to improve the concept until it satisfied TTH and SIS. This presentation is in Dutch and can be found in Appendix K. The visuals from the presentation are used in this section for illustration purposes.

The Multimedia guide is responsible for enhancing the museum visit. The model of the Virtual Circle-(chain) is used to support the relationship between visitors and the museum.

This section presents the concept from the viewpoint of the user: first the pre-visit, then the actual museum visit and then the follow up activities during the post-visit.

5.4.1 Before the visit

In order to stimulate people to visit the museum and extend the museum experience to before the museum visit, on the museum website visitors can: play games, search for information about the museum and museum objects, book their tickets, fill in their personal preferences, set out a personal museum tour, print a museum's ground plan and possibly even download the multimedia guide onto their own PDA or Smartphone.

Figure 5.14: *An example of a webpage, used in the presentation for TTH and the City of Hengelo.*

To ensure that visitors see the Virtual Museum as one complete package, some metaphorical elements are used. When a visitor visits the Virtual Museum from his home via the internet his position is constantly traced like he would be in the actual museum. This can also work as a trigger to actually visit the physical museum. Figures 5.14, 5.15 and 5.16 visualize this idea of tracing the user's position on the website.

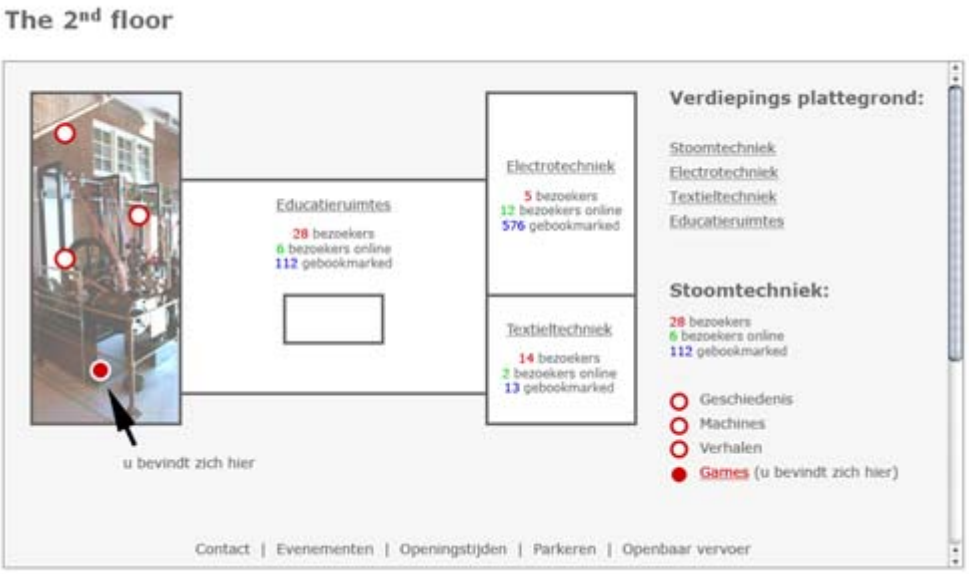


Figure 5.15: *An example of a webpage, used in the presentation for TTH and the City of Hengelo.*

The website contains a lot of information that is freely available. Through the website, visitors can access the online library catalog, an multimedia catalog of items in storage, historic pictures and photos, interviews with volunteers and the platform for contributions from the public (www.geheugenvanhengelo.nl) that will be linked to the Virtual Museum. The community can grow by linking websites from other similar museums to it, and websites like Wikipedia.

Figure 5.16: *An example of a webpage, used in the presentation for TTH and the City of Hengelo, whereby the position on the website is tracked.*

5.4.2 During the visit

With the multimedia guide, the user can access information about objects in his vicinity; this information is adapted to his personal preferences. The PDA could, for example, be attached to the wrist in order to have both hands free (requirement 21) as visualized in figure 5.17.

Figure 5.17: *An example of a Information Assistant whereby the Assistant is carried around the wrist.*

With the Information Assistant, visualized in figure 5.18, visitors can view and/or listen to personalized information. The user is in control of the amount and which information he consumes, and can bookmark objects to review them at home. Many types of media can be used on the PDA like text, audio, movies, pictures, games and animations. The Information Assistant is based on web technology and therefore independent from a type or brand of PDAs. Only touchscreen buttons will be used so hardware buttons will not confuse the user (they will be covered by a casing), and museums can easily switch to other PDAs or mobile devices with a screen that can be carried around comfortably.

Figure 5.18: *An example of content on a Information Assistant.*

5.4.3 After the visit

When visitors visit the museum's website after a visit to the museum, they can log in on their personal part of the website to relive and expand their visit. Reliving and expanding the visit can be done by reviewing the multimedia information retrieved at the museum and by digging deeper into information that could not be viewed while at the museum. On the website, the visitor can look up his bookmarks, the objects he visited and the route he has taken through the museum (visualized in figure 5,19).

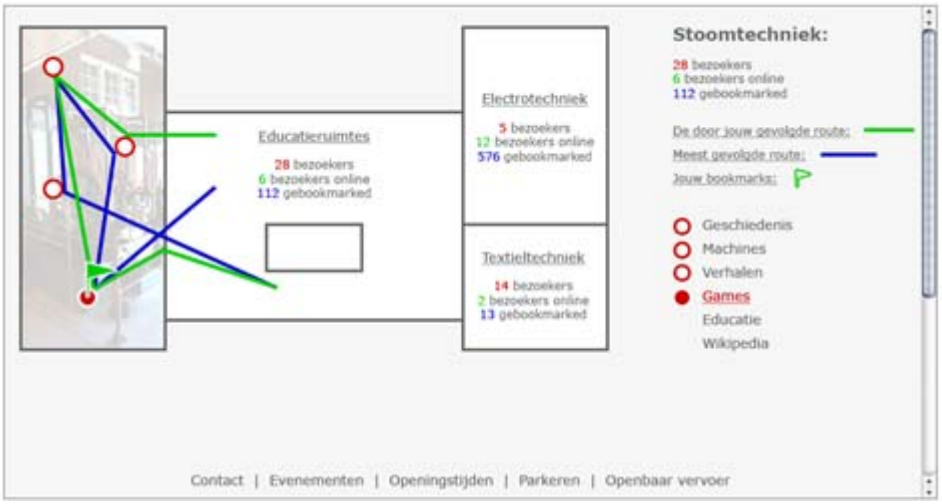


Figure 5.19: *An example of the website after the museum visit.*

5.4.4 Analysis tool

The Analysis tool is to be used by the museum to get insight into the flow of visitors through the museum, and how often an object is viewed and bookmarked. The generated data is presented in a visual way to give the museum staff a quick overview of the results. More statistics results can be retrieved, but the visualization of the data probably better encourage the user to study the visitor behavior.

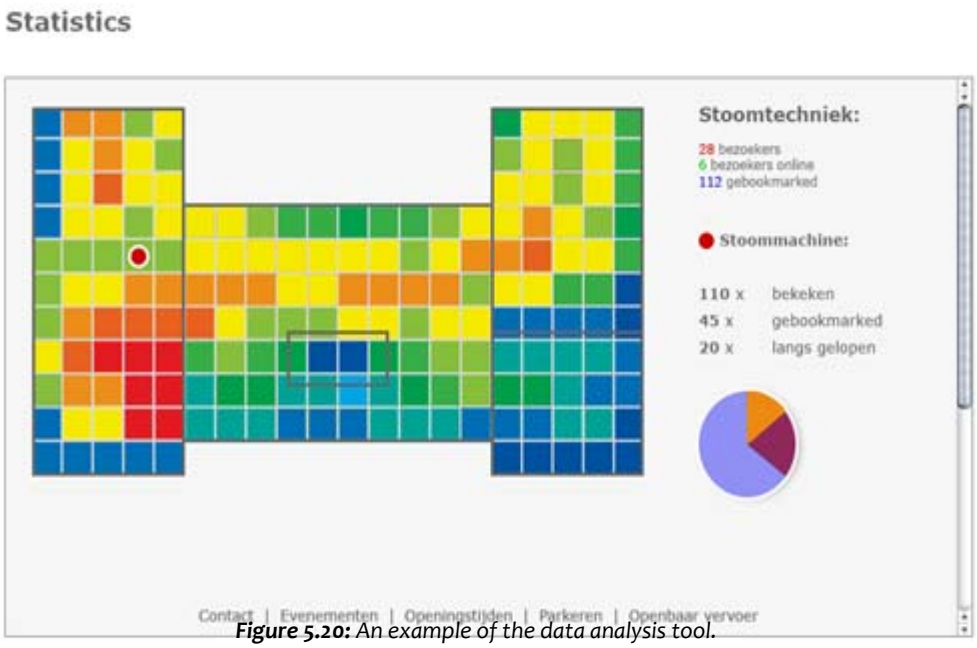


Figure 5.20: *An example of the data analysis tool.*

5.4.5 The Virtual Circle

The Virtual Circle encapsulates a visitors pre visit, visit and post visit to the museum and the transitions between these visits. The Virtual Circle can evolve into a Virtual Circle-chain by connecting the Virtual Circles from visitors. This can be done by building bridges between visitor during the museum visit: when they come to the museum as a group or when they play games together. Before the visit, website visitors can search through the bookmarks, shared photos and routes taken of people that already visited the museum. After the visit, visitors can send their bookmarks and photos to friends. The Virtual Circle with all supporting activities, is displayed below in figure 5.21.

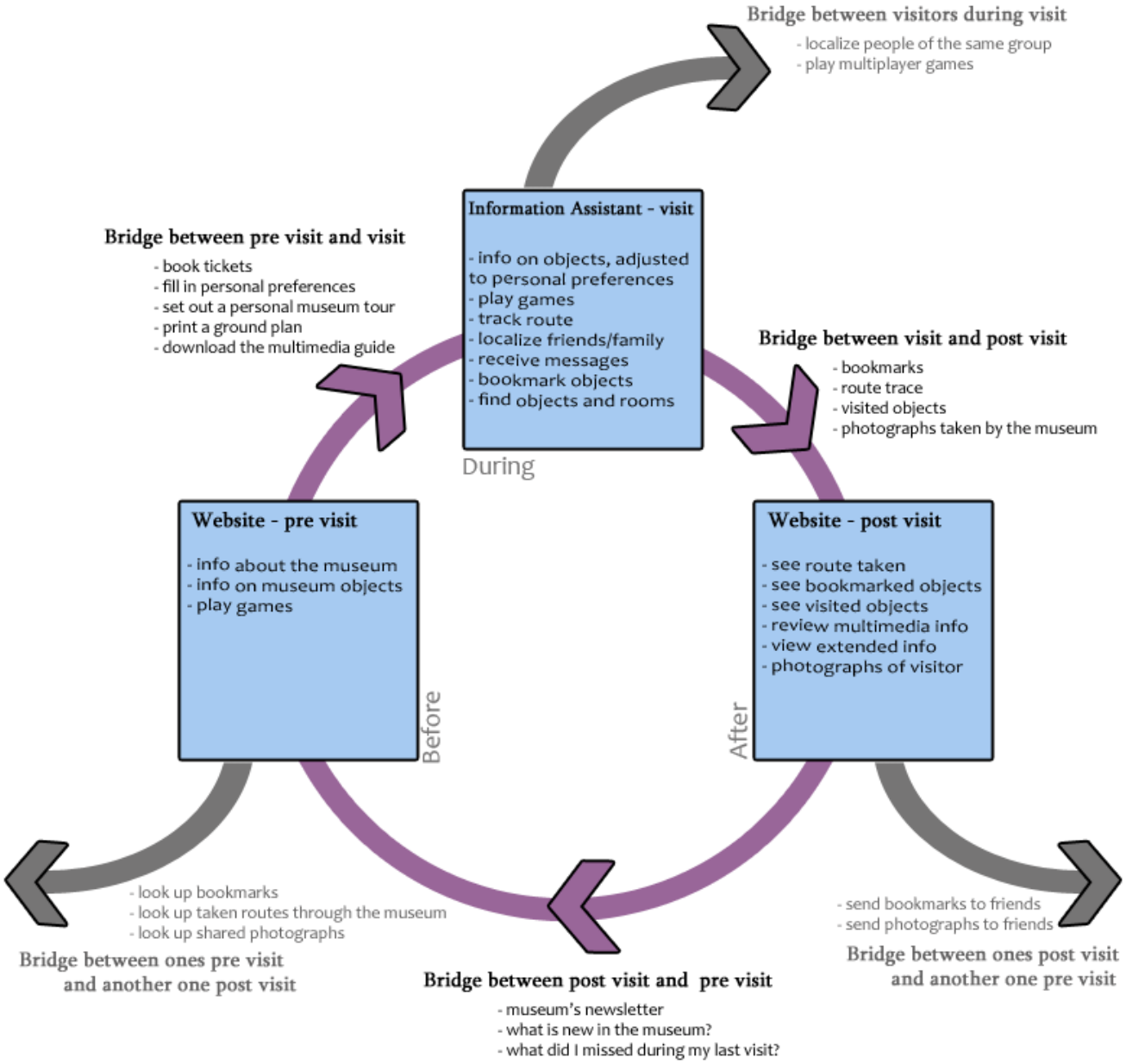
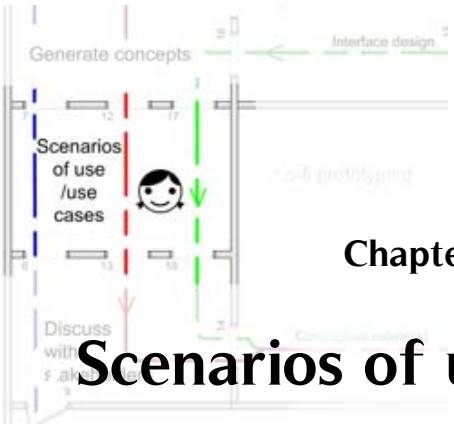


Figure 5.21: *The Virtual Circle, with all possible activities to support the different phases.*



Chapter 6

Scenarios of use/use cases

Scenarios have been used as a communication tool towards TTH and SIS as stakeholders. The scenarios of use that were written use information about the user needs from Chapter 3 and the concept of the Virtual Museum of Chapter 5 to test the concepts and to form ideas about possible problems that could occur and their solutions. From these scenarios some ideas about what users want from the product were extracted, which can be found in Appendix C.4, that can be useful in the further development of the Virtual Museum.

The scenarios of use have been translated to use cases to communicate them towards software engineers who are used to work with UML diagrams. Use cases are classes that define units of functionality or behavior provided by a system. They specify the external requirements of the system and the functionality offered by the system [20].

The scenarios (written in Dutch) can be found in Appendix D, in this Chapter only the pieces where interaction between user and the system take place are highlighted. Because this are the pieces that come back in the use cases and are of vital importance of the system.

6.1 The MuseumGuide

The following parts are extracted form Scenario 1: Grandpa Fred (78), mother Vera (43), father Ton (45), Patrick (16) en Eva (11).

Ask a question

- They receive a short explanation at the museum counter and when they need help on something while in the museum, there's a button on the PDA which can be pressed. A member of the museum staff or a volunteer will then walk towards them to help them out. -

The MuseumGuide must offer the possibility to ask a question to a volunteer or staff member through the Information Assistant.

Set preferences

- Vera has already filled out her interests on the website. She mentions her name to the receptionist, who enters it into the PDA. It is now configured to give priority to information she finds interesting. Eva and Patrick fill out their interests at two screens standing near the desk. -

- Grandpa puts on his spectacles, but is still having difficulty reading the letters on his PDA. Patrick has returned in the meantime and sets grandpa's font size larger. Now, Fred can read his screen perfectly. –

The MuseumGuide must offer the possibility to set preferences for the Information Assistant, these settings must be accessible through multiple platforms.

Show nearby objects

- Vera pushes a green button, on here screen the following appears:

Room: Textile

Objects nearby:

hand loom and sewing machine

Other objects in this room

- Patrick is now in front of a large steam-engine. After looking at it from different sides, he looks at his PDA to see if it has anything interesting to tell him about the machine. Patrick clicks on "Steam engine". -

The MuseumGuide must be able to show the user the objects in his vicinity.

Bookmark an object

- Vera is never tired of looking at it, she finds it all interesting. She decided to bookmark the 150 years old loom. When being at home she can look at the information again at ease. -

- Patrick is curious what will happen if he clicks the flag icon at the top. On the website, Patrick has read it will be 'bookmarked', so he can easily find more information about the machine afterwards. -

- Grandpa Fred finds the PDA contains a bit too much information for him to keep up with. There are so much interesting facts! Ton explains to him he can click the flag at the top if he wants the system to remember his interest in a certain object. Later, when he's visiting Ton and Vera, grandpa can review everything he bookmarked on their computer. -

The MuseumGuide must offer the option to bookmark objects and review them on the internet.

Get museum object information

- Eva tells Grandpa he can click everything that's blue and underlined to view related information, and assures him nothing can go wrong. He leaves the stylus on the PDA for what it is, and presses the words "Wooden clock" with his fingers. Sure enough, something happens! -

- Patrick clicks on "Steam engine". He now clicks the "Animation" link at the bottom. -

The MuseumGuide must provide the user with the object information the user asks for.

The following parts are extracted form Scenario xx: Patrick (16) and the old telephone.

View map

- He gets his PDA back in his hand and looks at the map of the Telephone room which is displayed on the PDA. On the map he sees the face of his Assistant and around it colored areas that present the museum objects. The Assistant is standing almost on one of the objects, by looking at the form and location of that object Patrick assumes it is the old telephone where about he wanted to have information. -

The MuseumGuide must display a map on the Information Assistant and show the user his location on that map.

The following use case (figure 6.1) visualizes the functional requirements and the interactions between the MuseumGuide and the actors of the Museum System. The use case was extracted from the two scenarios above and fulfilled with options that will probably be of importance to other/bigger museum. These options are already considered here because eventually they will have to fit in the system that will be developed.

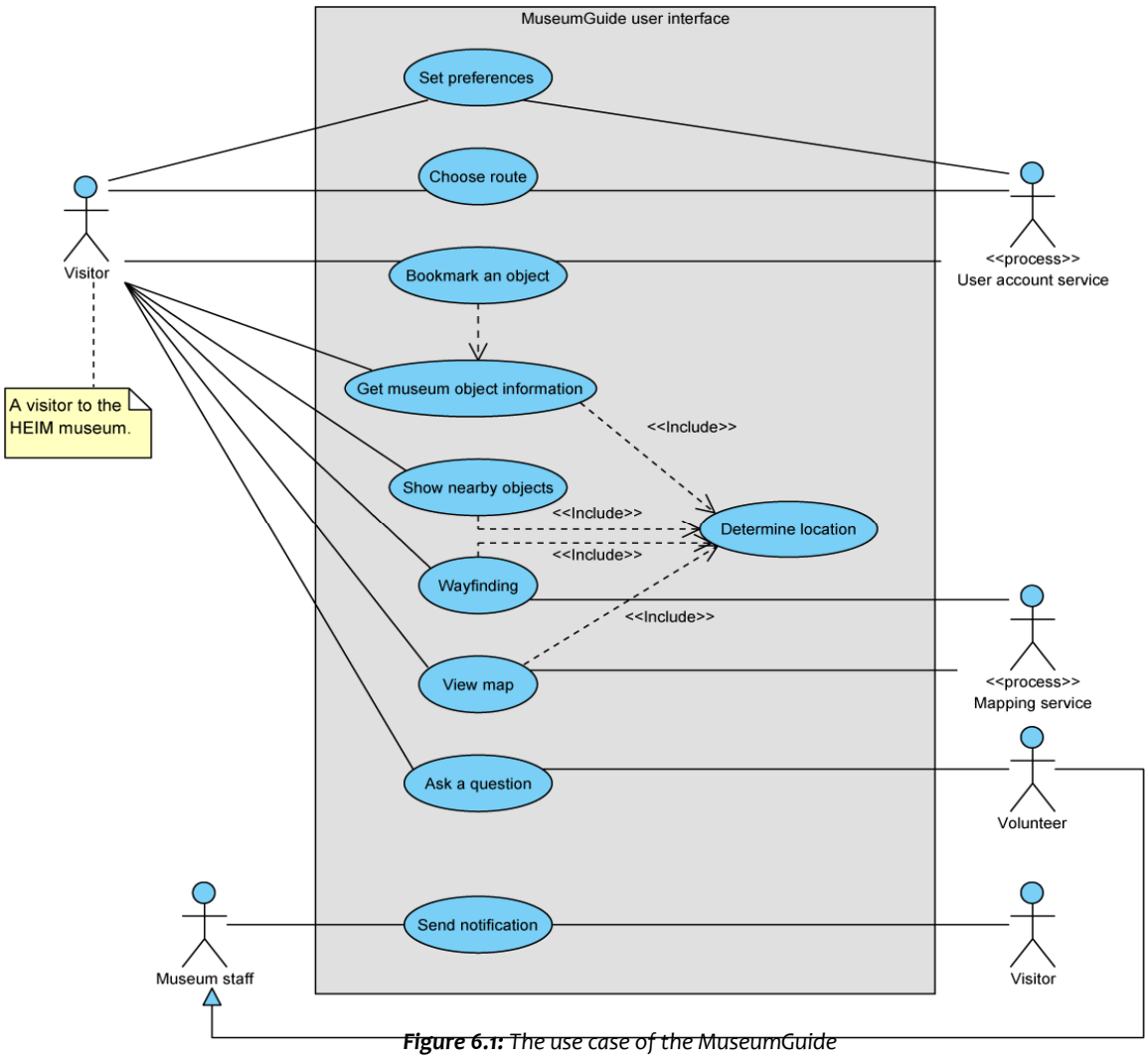


Figure 6.1: *The use case of the MuseumGuide*

The functions **Choose route**, **Wayfinding** an **Send notification** were not mentioned in the TTH's scenarios of use. Choose route and Wayfinding are options that we include in the system but are not strictly necessary for the TTH's Virtual Museum because this museum is rather small. If one would take a museum like the French Louvre in mind, these options would make more sense and be very handy to have. With **Send notification** a museum can send messages to visitors via the WLAN, this messages could include the time for the next show or a special offer at the museum café.

6.2 Analysis tool

The following parts are extracted form Scenario 2: Conservator Cornelis (33), managing the museum.

View statistics and **View map representation of statistics**

Something that can aid Cornelis in his decisions is a new system the museum has recently been equipped with. This system can determine the location and routes of visitors through the museum. Not only does this have advantages for the visitors themselves, who receive information about the objects directly surrounding them, but the museum also gains valuable management information. Cornelis can see on his computer how often an object is bookmarked by visitors, how many viewed a particular object or passed through an area. It appears the dead-end hallway with the emergency aggregate is only visited by 15% of the museum's visitors.

The Analysis tool must show the Conservator statistic information about visitors' behavior and visualize this.

This following use case (figure 6.2) visualizes the functional requirements and the interactions between the Analysis tool and the actors of the Museum System.

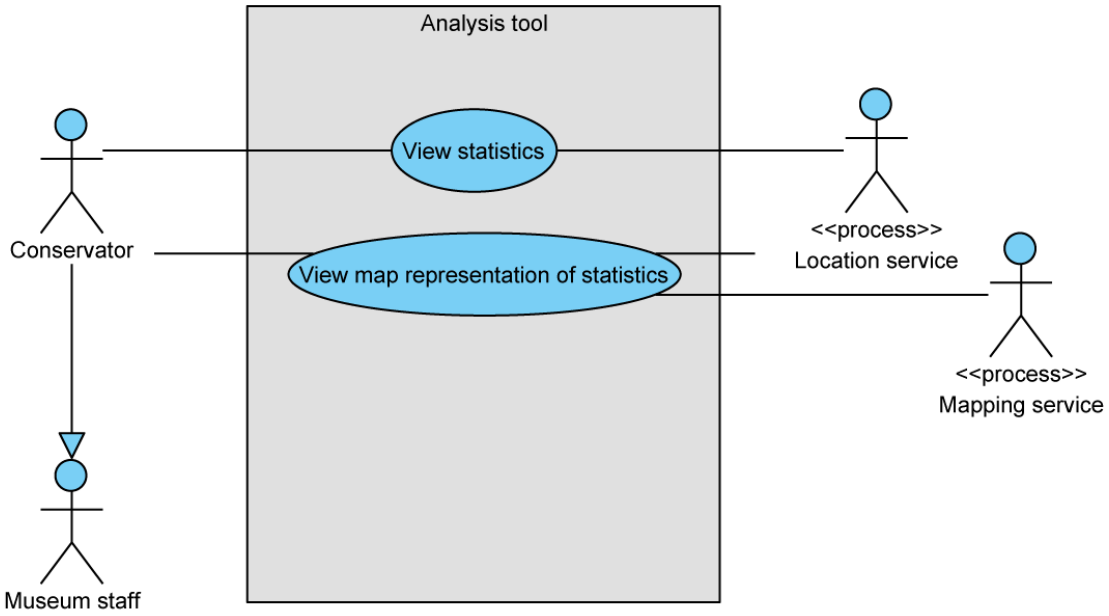
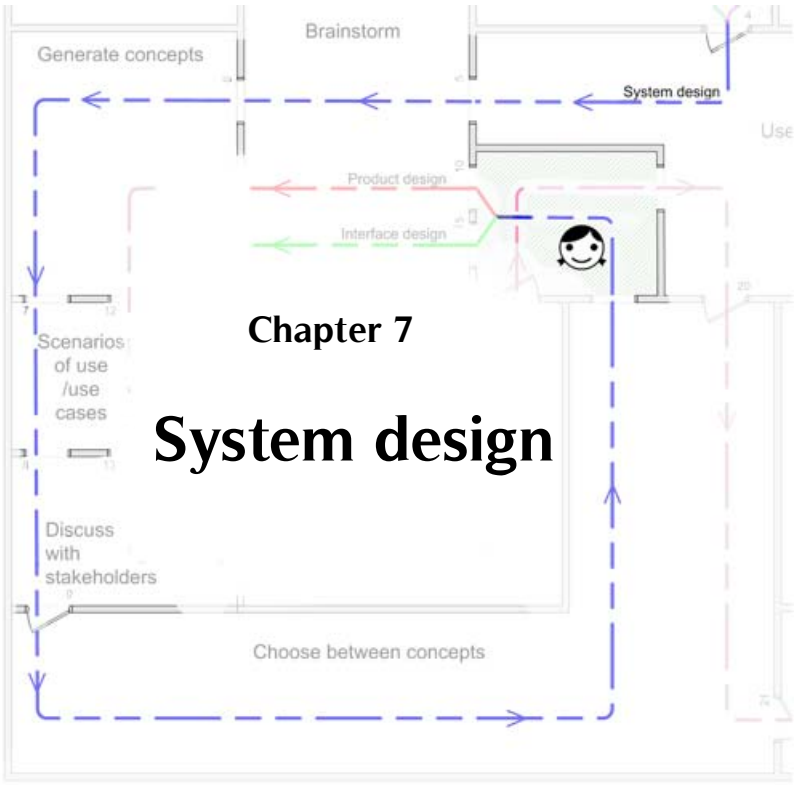


Figure 6.2: *The use case of the Analysis tool*



Chapter 7

System design

The purpose of the Virtual Museum is to attract people to (re)visit the museum and involve people with the museum. The six pillars of the Virtual Museum have already been introduced in Chapter 5: Designing the Virtual Museum, four of them are further developed in this chapter.

In this chapter, as well as in the whole report, the main focus is on the Multimedia Guide that enhances the visit and makes use of positioning technologies and the personal preferences of an user. Section 7.1 results in a design for the hardware part of the Multimedia Guide, a description of the functionality of the software part and guidelines for the bookmark tool that forms a bridge between the Multimedia Guide and the museum Website. For the Website, the pillar described in section 7.2, specifications are given with al the functionality and components it should posses. Section 7.3 gives an initial concept and some guidelines for the Front Desk, which purpose it to update and recharge the devices and handing them over to visitors. The Content Framework described in section 7.4 is a framework that the museum can help in creating content, it consist of guidelines and specification to make the content for the website and information assistants.

The design of the LBS pillar, to determine the users position, is part of a separate master thesis an described in 'Design and implementation of a protocol and prototype for indoor positioning' [12]. The Back-end pillar, containing a CMS and data analysis program, is not further developed because its users are not the museum visitors but the museum itself. And because this pillar is not necessary when building an initial Virtual Museum and to test if in enhances the visit and visitor involvement. For the Virtual Museum to stay alive, however, it is vital.

The six parts of the Virtual Museum are called pillars because they form the foundation of the Virtual Museum. When the TTH wants to open its Virtual Museum all pillars have to be present, otherwise the Virtual Museum will stagger.

7.1 Multimedia guide

The job of the multimedia guide is to provide visitors with a personalized entertaining experience through which they learn about the cultural heritage in and around the museum. It also collects information about visitor behavior, which can be used by the museum to improve the experience.

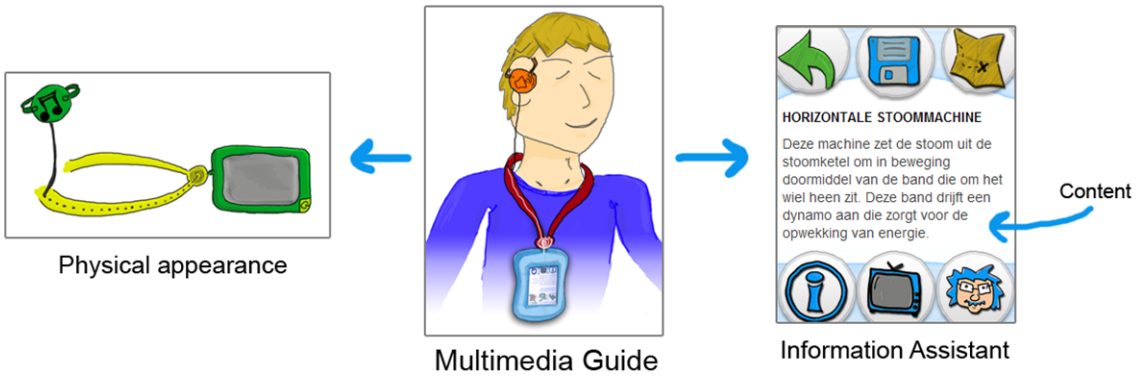


Figure 7.1: *The Multimedia Guide can be split into two parts*

The Multimedia Guide, which users carry with them during a museum visit, will be treated in two parts: Firstly, its hardware and secondly its software. The physical appearance, casing and the way to carry the device, are only described conceptually enough to use it for the demonstration that was held in TTH to test the Multimedia Guide. Section 7.1.1 results in a design for the hardware and a list of guidelines for the casing of the Multimedia Guide. The graphical user interface is treated in section 7.1.2 and elaborated on in Chapter 9.

7.1.1 Physical appearance

The graphical user interface is the face of the Information Assistant which is independent of the type of device as long as it runs certain components and has a touchscreen. The Information Assistant designed for TTH runs on different types and brands of PDAs. Therefore, the physical appearance is described for a PDA. The hardware of the Multimedia Guide is only described conceptually, enough to use it for the demonstration that was held in TTH to test the Multimedia Guide. The hardware supports and enhances the user experience of the software. The physical appearance of the Multimedia Guide consists of a:

- PDA;
- casing for protection, covering the buttons and creating an overall look and feel;
- way to carry the device;
- way to listen to the audio;
- volume control to adjust the audio volume.

PDAs

A PDA is a hand-held computer and come in different sizes and with different technical specifications. Different types of LCD (liquid-crystal display) technology are used for the displays: transmissive, reflective and transflective. Transmissive displays use a backlight, which makes it perfectly viewable indoors. Outdoors the screen is only readable in the shade because sunlight overwhelms the backlight. Reflective displays use ambient light that is reflected by a mirror in the screen. They can be used in a bright light environment. Together with a build in frontlight they can also be used in less bright environments. Transflective screens use a backlight and a reflective mirror, making it viewable under both , indoor and outdoor, lighting conditions. However, the are not as bright as transmissive screens indoors and as reflective screens outdoors, but can be used in both environments [21].

The screen size is mostly 3,5" or 2,8" and has a resolution of 320x240 or 640x480 pixels. The resolution is independent of the screen size. Because the Multimedia Guide has to be type and brand independent all these PDA characteristic have to be taken into account. However, when the museum chooses his PDAs it is advised to choose for 3,5" transmissive screens, with a resolution of 640x480 or higher if available.

Casing

Making the Information Assistant PDA type and brand independent (req. 12) can be accomplished when only the PDA's touchscreen is used. Therefore, the hardware buttons must be covered so the user will not be confused by buttons or elements that are not in use (req. 9). A casing is also necessary to prevent users from taking the device apart (req. 16), and to make it more shock resistant (req. 17). The casing of the PDA could have the added functionality of being able to block the sun, so that the content on the screen is readable when it is used in direct sunlight (req. 15). A design for a casing that is helpful in blocking the sun can be seen in figure 7.2.

A problem with designing a casing is that the casing must be tailor made for the different PDA sizes or one casing has to be designed that fits all PDAs. A solution is to take one standard size, and fill up the difference with a material that is light and can absorb shocks.

For the TTH a casing is not made, during the demonstration the PDAs were wrapped in foam tape and isolation tape to cover the buttons and to protect against dropping. Some designs for the casing were made (figure 7.2), including a Solid Works model. A casing was not found to be crucial to test the Multimedia Guide.

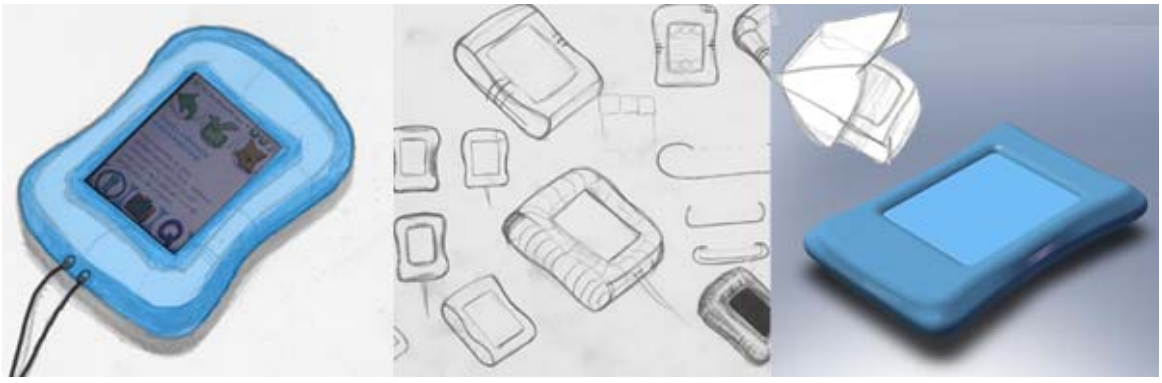


Figure 7.2: *Sketches and a model for the casing*

The results of this section are a list of guidelines for a Multimedia Guide casing; these guidelines can be found in Appendix H. Most important ones, not mentioned before, are that the casing has to be light weight, that staff members have to be able to press the reset button and visitors not and the on/off button should be reachable by both. No metal can be used near the GPS antenna, because it will interrupt the signals.

Carrying the device

As stated by requirement 14 there must be some way to carry the device comfortable, because users have to find it comfortable to carry and use the device during a museum visit.

To ensure that users have both hands free (see section 5.4.2), the initial idea was to carry the PDA around the wrist, as showed in figure 7.3. This idea was presented in the concept presentation towards TTH and the City of Hengelo. This idea has been tested by attaching a PDA to the wrist with tie rips during a work day. It was experienced that, although the weight is not high (approximately 200 gram), it becomes heavy because one is not used to have that weight carried around the wrist. Also, as in order to let the dominant hand interact with the PDA, the weaker arm has to carry the guide. The PDA would be attached to the left wrist for people who are right handed and vice versa. Another reason for dropping this idea is that people could, for example, easily graze a door-post when they walk trough a door, because the PDA will make them broader.

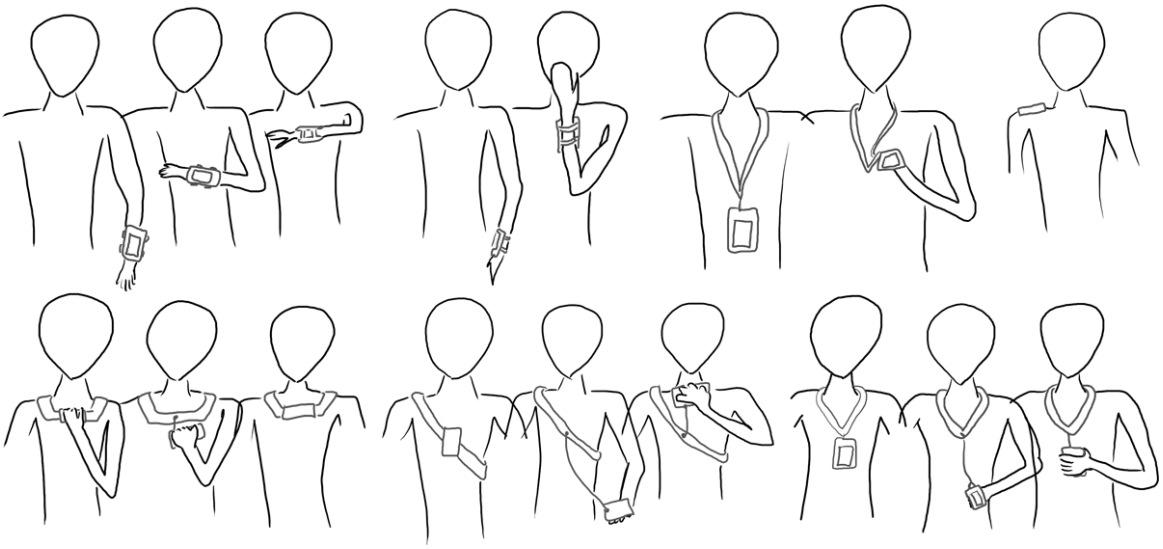


***Figure 7.3**: Different ways to carry the guide*

A solution that is used by all tested multimedia guides is a (key) cord. However, a cord that reaches the chest of one person can hang on the belly of another person. Also, since people differ in length, the size of people's head varies, and it must be possible for all to get the cord around the neck. For example, in the Boijmans van Beuningen museum the key cord is rather long, making it easy to get ones head through the loop. A disadvantage is that it causes the PDA to hang before the vital parts, bouncing up and down when walking. This problem mitigated, when the PDA is not only worn around the neck but also around one shoulder, as experienced during testing the Boijmans van Beuningen multimedia guide.

So what is needed is a key cord that can be long when placing it around the neck and for viewing the screen, and small enough to walk comfortable with it. A solution was found in using a retractable reel between the key cord and the PDA, which would extend the key cord when pulled out. Figure 7.4 shows different concepts that use a retractable reel. A problem with retractable reels is that small ones are not strong enough to stay unrolled when the PDA is attached, and the stronger ones are too big and heavy. Also, heavier ones have to keep up their own weight as well.

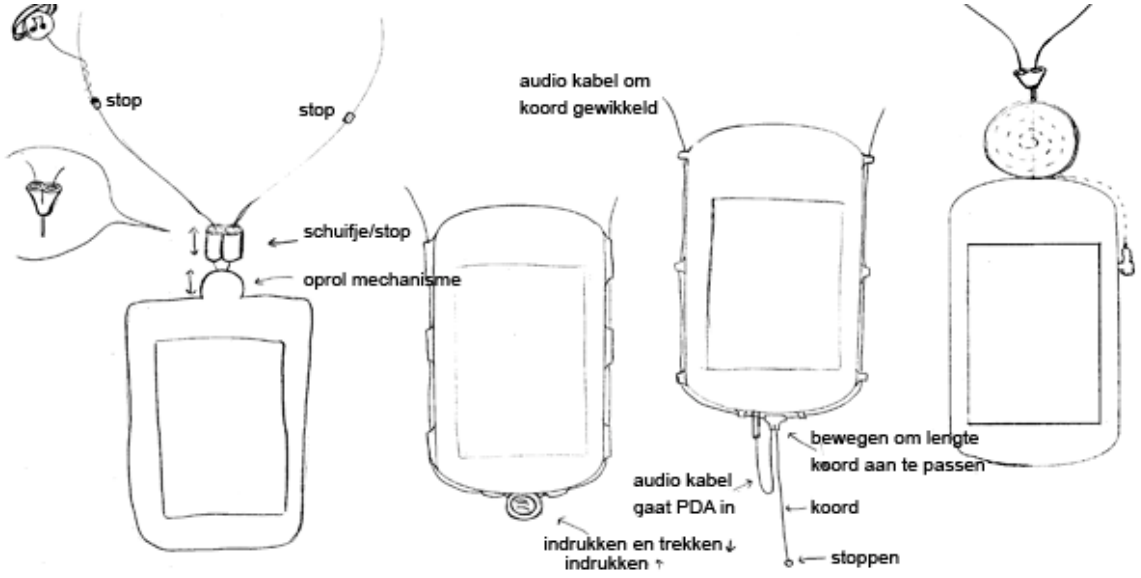


Figure 7.4: *Different concepts that use a retractable reel*

An attempt was made to build a mechanism with more than one small retractable reel, so they can keep up the weight of the PDA (see figure 7.5, the 3rd picture). A second option was to place such retractable reel horizontal so that the cord that goes through the reel has more friction and can hold more weight (see figure 7.5, first two pictures). The major difficulty for this solution was the audio cable that has to go through the retractable reel as well, because wireless earpieces (Bluetooth) were not found to be useful; they create static noise when no audio signal is present.

Figure 7.5: *Prototypes of a cords with retractable reels*

Several problems were unveiled testing the prototypes, presented in figure 7.5 above. When the PDA is pulled down it is also felt as pulling at the neck. Also, the tract and retracting of the cord did not go as easy as expected. The retractable reels have some points at which they can hold the cord in position, these points have to be found by the user by pulling the cord in and out. When a little metal ball is removed from the reel, the cord goes more smoothly and can be kept up at every height, but only if there is enough friction to keep up the weight of the PDA. Unfortunately the PDA's weight is too much to keep the cord unrolled when not using the reel's metal ball. Another disadvantage of the retractable reel solution is that it contains moving components, which makes it more vulnerable.

The option that works best is therefore to use a cord. Instead of a key cord, which is common at Multimedia Guides, a broader elastic cord is used because we expect it to be more comfortable.

Earpieces

Earpieces or headphones must be provided with the Multimedia Guide because the user should not bother, or be bothered by, other users working with the system (requirement 3). A headphone would isolate the user from his co-visitors and detract him from the social part of the museum visit, but according to requirement 8 the museum visit must remain a social experience. Keeping one ear free to listen to other visitors or sound coming from objects, can be achieved by using one earpiece per person instead of two. To ensure that earpieces are not lost, they have to be attached to the casing and the key cord.

***Figure 7.6**: Single ear earpiece made from a headphone.*

Bluetooth earpieces were initially seen as a technique that could enable two people to listen to the audio of one device simultaneously, without having to stand next to each other. This would for instance be very useful for a group of schoolchildren, and is also described in the scenario which can be found in Appendix D.

Unfortunately, nowadays PDAs can only send the audio signal to one earpiece or speaker at the same time. While testing the Bluetooth earpieces it was also found that they tend to make a cracking sound when no audio signal is send to the earpiece, which was found to be irritating. Based on this, Bluetooth earpieces will not be used.

Earpieces with an audio cable turned out to function better. They can be divided in two groups, in-ear earpieces and earpieces that are placed around the auricle. In-earpieces might be classified as unhygienic by visitors, leading to the fact that they do not use them. Therefore earpieces will be used that hang on the auricle, like the one in figure 7.6, instead of being placed inside.

Volume control

The volume must be adjustable in a single action, and the volume control must be easy to find (requirement 19). This means that the volume up and volume down buttons have to be present in the UI on every page that contains audio, or the volume must be controllable with a hardware component. A PDA might have a volume scroll button, but this is not consistent. A solution is to use a volume control attached to the key cord on the audio cable. For volume up the user has to scroll the wheel up.

Conclusion

The physical appearance, displayed in figure 7.7, consists of three different parts attached to each other: a casing, a cord with a retractable reel and volume control, and an earpiece. Because no retractable reel was found that was strong enough to keep up the PDAs weight, a normal cord has been used during the demonstration. Because the TTH is very noisy, two earpieces are attached to the PDA instead of one, so that with lots of noise user can put on the second earpiece as well. This solution is not ideal because it can isolate the user as stated in section Earpieces above.

Figure 7.7: *The Multimedia Guide's physical appearance*

7.1.2 Graphical user interface

The graphical user interface is in fact the Information Assistant as displayed in figure 7.1. The Information Assistant is based on web technology and can therefore run on all kinds of platforms that can run Web applications. The information assistant is an information source that is aware of his surroundings and environment. Using this knowledge, it can efficiently communicate with the user through the multi-media device. The information (content) is also accessible through other means of interaction, like for example through the museum's website.

The way people want to interact with the Information Assistant, and the information they want to gather, has to be determined before designing the graphical user interface. This is done in the first section: Functionality of the Information Assistant. To prevent that the Guide's most important functions are overshadowed by the extra functions, and making the device unnecessary complicated, the basic functionality and extra functions will be separated. The second and last section treats 'The

Assistant' a button in the form of a face on the map of the Information Assistant. It shows the user its position on the map and gives access to all extra functions of the Guide.

Functionality of the Information Assistant

Museum guide users can be classified into three groups, in terms of the viewing habits and interest: greedy users who want in-depth information on everything; selective users who want in-depth information on selective items; and, busy users who want to see a little bit of everything [22]. To satisfy all three user types, the guide should offer layered activities so that users get basic information on an object and can choose to receive more in-depth information. These layered activities are also recommended by several museum study researchers, according to Hornbecker and Bartie [17]. Besides, give low information first and move to more in depth information was also a function of the multimedia guide that resulted from *Chapter 3 User needs*. With the Multimedia Guide the user is in control of the information he consumes, so he can choose the amount and depth of the information he consumes.

Giving access to those layered activities (chunks of object information) is a basic function of the Information Assistant, together with helping to navigate through the museum and giving the possibility to bookmark objects. To keep the Information Assistant as simple as possible, but also functional to a broad extend, all extra functions are mapped under one button. Users who do not want to use the non-basic functions will not be bothered by them and users who want to use them can easily reach them. This button is the Assistant itself. The extra functions of the Information Assistant are: showing the positions of the user's friends; sending museum notification towards the user; showing the battery state; giving an overview of the objects bookmarked by the user; mapping a route to a specific place or object; search functionality; and changing preferences. By splitting up the basic functions and the extra functions, the basic version can be tested without the extra functionalities.

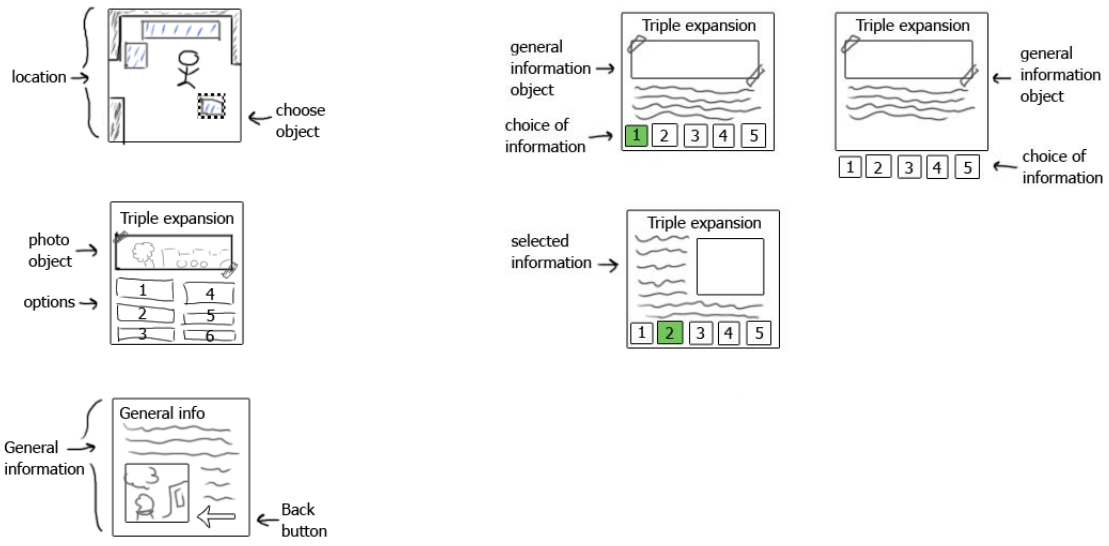


Figure 7.8: *An initial interface concept, based on the basic functions*

In Section 5.2.3, it has been concluded that a map would be a good start page for the Information Assistant. Figure 7.8 shows an initial concept based on the basic functionality.

The Assistant

The Assistant is represented by a characters face. The face is placed on the electronic map and shows the user his location. By clicking on the Assistant the user gets access to the extra functions. The Assistant has a face because it is expected visitors are more willing to interact with a system if they perceive it as being more human, with a friendly and polite personality [6].

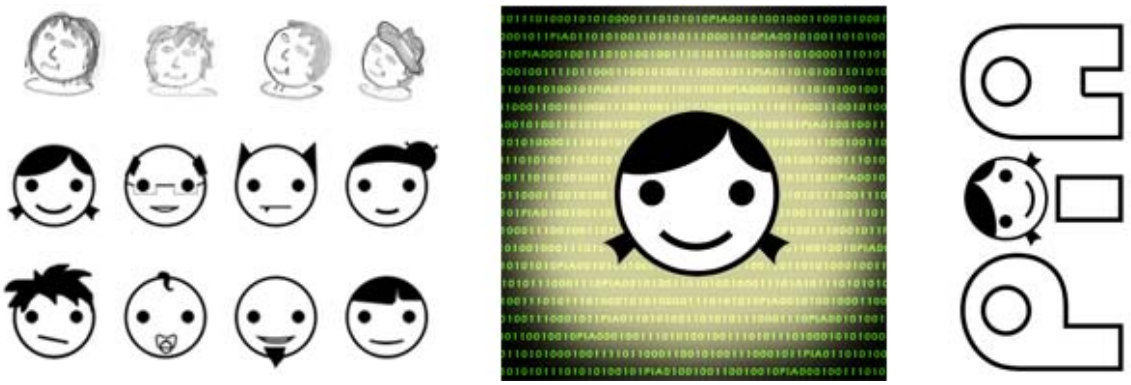


Figure 7.9: *The Assistant, initial sketches of the Assistant, family members and a logo for PIA.*

The name of the Information Assistant that was developed for TTH is PIA. PIA is an acronym for Personal Information Assistant, but also for Persoonlijke Informatie Assistent and Persönliches Informationen Assistant. English, Dutch and German are also the three languages in which TTH would want to present the information.

The character PIA can also be used in choosing the personal preferences, in that case different family members of PIA are used for different age groups (see figure 7.9).

Bookmarking

A Bookmark tool can be a method for bridging the gap between the visit, where people interact with the Information Assistant, and the post visit, on the website [23]. People like to take something home from their visit, to remember the event [10]. Two thirds of museum visitors also want to engage in a follow-up study on what they learned during their museum visit [17]. A bookmark tool allows users to save information they are interested in at the museum, so they can review the information at home. Back home, the visitors could access these bookmarks via the museum website and extend the museum experience. Bookmarking is above all a useful tool for visitors with a specific educational or research purpose in mind, like researchers and returning visitors [23]. For schoolchildren en students who visit the museum, the ability to bookmark objects and review them later mean they do not have to scribble presented information down on paper.

Since the late 1990s, several museums have introduced bookmarking in various forms on PDAs, kiosks, and the Web. Most of these systems were not able to record useful information like the number of visitors and bookmarked items. Filippini-Fantoni and Bowen researched the three goals most museums hope to achieve with a bookmarking system: if bookmarking can extend the museum experience; if bookmarking can build a stronger relationship between visitor and museum; and, if it facilitates the learning process. To be able to answer these questions, they investigated several multimedia projects with bookmark functionality from different museums. They found the Tate Modern bookmarking system to be the most successful one. In the summer of 2005, 40 % of the PDA users used the bookmark functionality in the museum, and 19% of the PDA users reviewed their bookmarks on the museum website [23]. So the percentage of visitors that accessed their bookmarks was slightly below the 50%. The same percentage was found by other researchers that evaluated the bookmark system of the Technical Museum Vienna. Their evaluation also revealed visitors were more likely to bookmark an object so they could visit the object information when they are at home, than they were to read a lot of information at the museum [17].

The success of bookmarking solutions is below museums' expectations. But according to Filippini-Fantoni and Bowen bookmarking has proven to be one of the most effective tools to support museums' need of extending the museum experience beyond the museum walls. Bookmarking can be a powerful tool to increase visitors' knowledge about a collection or exhibition. And if it is well integrated in the visitor experience, it can create a stronger relationship between the museum and the visitor [23].

Lack of interest and time, fear of junk e-mail and information overload are user characteristics that negatively influence the success of bookmaking tools. Other reasons include visitor not being aware of the bookmark functionality, visitors not being aware of the ability to lookup their bookmarks on the museum website and lack of visibility for the bookmark tool [23]. Bad technical implementation on the museum's behalf can also cause negative visitor experience with bookmarking, as evidenced by this record of a visit to the Museum Vleeshuis in Antwerp:

> *"With the stylus I touch the blue button(see figure 7.10) with an envelope on it. The system gives an error and I get to see script code. The application has halted, it does not react anymore. I have to go back to the counter. The problem is that no email-address is filled in on the system. At the counter I get the opportunity to fill in my email-address on the device. Normally this step is skipped at the counter. Unfortunately I never received my bookmarks in my email-box."*

Figure 7.10: *bookmark tool from Museum Vleeshuis*

To improve the success rate of the bookmark functionality, museums should put more effort in advertising the functionality, both online and on site, to make sure that visitors are aware of the functionality and know how to use it.

To summarize, bookmark functionality should follow these guidelines:

Guidelines for a bookmark tool

The bookmark tool must be:

- well integrated in the visitor experience;
- advertised online and onsite and specially aimed at the committed visitors;
- visible to the visitors;
- transparent, intuitive and easy to use [23].

The bookmark functionality must be:

- explained , so that the visitor is aware of the functionalities it can offer before, during and after the visit;
- understood by the users.

7.2 The website

The museum's website informs and stimulates visitors to visit the museum. After a museum visit, visitors can expand, re-live and share the experience on the museum's website as already stated in section 5.3.3 (Relive and expand the visit). The website can give visitors the possibility to plan a route through the museum and review their bookmarks, made in the museum, afterwards. The website is also used to involve visitors and to stimulate visitors to revisit the museum.

According to research from Letty Ranshuysen, the Internet has fourth place in the ranking of information sources that stimulate people to visit a particular museum. The most important information channel is an earlier visit to the museum, second is an article in a newspaper or magazine and the third is mouth-to-mouth advertisement. Internet is becoming more important as an information channel.

Most museum website visitors look for information about recent exhibitions. They particularly value the option to browse through the collection database and to get information and stories about museum objects. Furthermore, information on special events, directions to museums, an appropriate image of the museum, information on research, contact information and the possibility to buy gifts and tickets online are valued by museum website visitors [24]. Besides buying gifts and tickets, which are the least important ones, these options should be incorporated in TTH's website.

Besides giving information, the website can also be used to visit the museum virtually. Frequent museum visitors often visit the museum virtually, but these virtual visits do not come in place for real visits [25]. A big advantage of virtual museum exhibits is that they can be accessed 24 hours a day and visitors do not have to travel. Virtual exhibitions can increase the reach of museums and make people more familiar with the museum. Components of a well-constructed virtual museum exhibit are: audio explanations or narration; interactive tools to get visitors more involved; plenty of information, even though visitors may or may not click to access it; many attractive graphics using elements like bright color schemes, logos, icons, and illustrations; and, clear and organized icon design [26].

Teachers, who want to plan and prepare a museum visits online like making their own tour [23], can also easily use virtual exhibits in the classroom as a teaching tool because it is accessible over the Internet [26].

Making information from PIA available on the website also can be seen as a virtual exhibit. All five components of a well-constructed virtual museum exhibit are incorporated in the information possessed by PIA. And if the visitors are able to access each others bookmarks, it can create a kind of virtual community [23].

Conclusion

The needs of museum website visitors, the components of a well-constructed virtual museum exhibit, the aspects that should be facilitated by the website to fully support the Virtual Circle (section 5.3.3) and the component for which the Virtual Museum should allow integration (section 1.2) together form the specifications for the Virtual Museum website. Figure 7.11 shows these elements placed in their position within the Virtual Circle. The mijnHEIM (myHEIM) part is the part the visitors have access to after the museum visit by means of their email address.

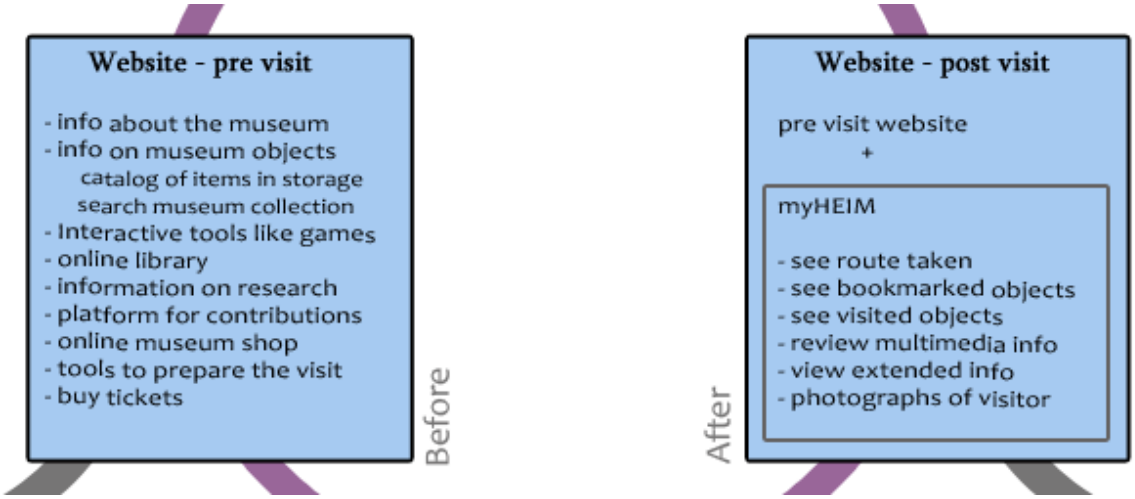


Figure 7.11: *The functions of the website, placed within the Virtual Circle.*

7.3 The front-desk

The Front-desk is a physical location in the museum where one or more museum staff members store, recharge, update and clean the museum guides. At the Front-desk, instructions are given to users. Just like in Museum Vleeshuis in Antwerp the Front-desk can be equipped with a screen that shows pictures of the Information Assistant. The museum employee hands the guide over and collects some personal data from the visitor, like a copy of his driving license, in order to prevent the guide against being stolen. A registration terminal can also be part of the front-desk to fill in personal preferences and the user's email address to review bookmarked objects at home.

This section describes update and recharge in section 7.3.1, theft protection in 7.3.2 and a registration terminal that is needed to obtain the user's email address in section 7.3.3. It results in a temporal solution for update and recharge, a procedure to prevent theft and guidelines for a registration terminal.

7.3.1 Update and recharge

The Front-desk must offer staff members the possibility to update and recharge the Multimedia Guides (requirements 28 and 29). Two different solution were found during market research.

The first uses a rack solution to recharge and update the boxes. This rack can also be used to present the devices like in the Museum Vleeshuis in Antwerp, where the whole wall behind the Front desk is used to store the PDAs. Colered LEDs on the rack can give the museum staff information about the charge and/or update states of each device. These LEDs have to be visible when standing before the rack and not, as in the Van Gogh Museum according to the front desk staff members, only when someone gets down on the knees.

The second solution for update and recharge, as performed by Ecomare and MOA, is plug the PDAs onto their adapters to charge them and connect them to a PC to update the content.

In the start-up phase at TTH the second solution will be used because it does not require a custom build facility. Eventually it is important that charging and updating the devices takes as little labor as possible and is fast, However, this is not a priority in the start up phase.

7.3.2 Theft protection

In a museum where the Information Assistant is only used indoors, the PDAs can be protected against theft by using an alarm that works the same as the protection of products in a supermarket. This kind of theft protection will also lower the threshold (requirement 2) for visitors to use a guide. In the case of the TTH visitors will be allowed to take the PDA outside the museum.

That a signature or bank account number of a user is not enough to protect the PDA against theft can be illustrated by the experiences of the Groninger Museum (GM). According to Steven Kolsteren of GM a few of their guides disappeared while they asked a signature and bank account number of every user. He thinks asking for a Passport is a step too far, partly because giving a signature and bank account number was already something with which not all visitors were happy with.

The Droombeek foundation asks for a bank account number, copy of an identification card and signature. These papers are given back to the user when he returns the Multimedia Guide to show the user that they do nothing with those facts if the PDA is returned unharmed. It is not known If this solution works, because on the moment of the visit during market research it was not yet opened up for the public.

Droombeek's theft protection is the most extended one and will because of that also probably be the best way to secure PIA against theft at TTH.

Another thing that can be done to reduce the chances of theft is to give the casings of the PDAs a look that fits the museum. It is expected that people are less tempted to take a product home if it look as if it really belongs to the museum.

7.3.3 Registration terminal

Most important function of the registration terminal is to enter the user's email address, personal preferences can also be given in on the registration terminal. When the user's email address is known, it can be used to send the user a link to his bookmarked objects. Therefore it also need be known which Assistant belongs to which visitor.

Typing the email address on a PDA is a cumbersome thing to do because of the tiny touchscreen buttons that will be needed. Something outside the PDA is needed to enter the email address. The chances of faults increases when museum staff members are asked to enter the email address in, because the address can easily be misspelled. Registration can take place at the museum website, when the visitor is at home, or in the museum. The problem with a terminal at the museum is the fact that there has to be some kind of a connection between the user's Assistant and the terminal. This connection can be made physical, with a cable, or with a wireless protocol like Bluetooth, WLAN or infrared.

The screen of the Multimedia Guide can be used as output device, showing the user the email address he enters with a registration terminal's keyboard, and showing the personal preference options. The visitor must be the one that controls the system, PIA is just a guide. Visitors must be able to skip the personalization step and just start using the Guide without having to interact with the registration terminal

The following guidelines are a result of this section and should be used when developing the registration terminal.

Guidelines for the registration terminal:

- The inserted text has to be immediately visible on a screen; the user has to see what he or she is doing.
- People have to be able to skip the personalization step, because they must be in control of the system.

7.4 Content framework

The content of the Information Assistant is responsible of dividing the user's attention between objects and surroundings and the Multimedia Guide. It should be interesting to read, transfer knowledge and entertain the user. The regular texts used in the TTH were found not to suffice for the Information Assistant during user tests. Users found the texts to contain too much jargon and too dry. Additionally it does nothing to point the user's attention to its surroundings.

Guidelines with relation to education and entertainment do not fit inside the scope of this report. But because content is a very important pillar of the Virtual Museum, guidelines have been set up for text (section 7.4.1) and audio (section 7.4.2). Furthermore, guidelines are written that aim to improve user's division of attention using content, these can be found below.

In tested systems, dividing the attention is always done by means of the content of the guide. Possible ways are:

- The content (text or audio) can pinpoint the user to the object by describe a certain fact and tell the user where to look at.
- The content can tell the user things that he can see in his surroundings.
- Providing the information is small pieces instead of long texts that require attention.
- The guide can ask the user questions for which the user has to study his surroundings before he knows the answer.
- The guide can use audio instead of text or video so that the user does not have to look at the screen (figure 7.12 shows an example).

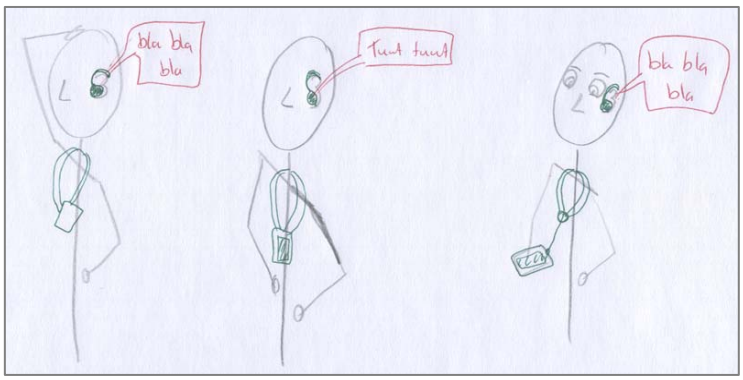


Figure 7.12: *The user is listening to audio, the assistant gives him a hint 'tuut tuut' when something appears on the screen.*

The different prototypes of PIA made use of different types of media; user's reactions on these media types are useful for further content for PIA. The user tests pointed out that the Quiz is the most popular media type followed by movies and animations.

Content can also easily be evaluated by testing it with users. This has been done with the content written for the demonstration. A test person was asked to view all content of the Guide and voice his opinions while reading. A report of this user test can be found in Appendix K.

7.4.1 Audio

The Information Assistant contains spoken stories, movies that contain audio and texts that are spoken in. Museum visitors remember more from an audioguide than from reading labels [17]. Audio also benefits people with visual and/or reading impediments like reduced visibility or dyslexia. Furthermore, a number of people prefer to listen instead of read, as was experienced during the user tests.

Another important advantage of audio is that when users listen to audio they can simultaneously investigate the museum object, whereas they would look at the screen when they read text.

The conducted research on Audio, which results in the following guidelines, can be found in Appendix G.1.

Guidelines for audio:

Speech rate: The speech rate of radio and TV newscast announcers is a good speed to employ for the spoken text.

Voice: Frequencies above 4000 Hz need to be avoided; therefore male voices are a better choice.

Sound volume: The user has to be in control of the volume.

7.4.2 Text

Text is used for general information, operation information, information about the inventor, quizzes and messages. General information, operational information and inventor information are also presented as audio. For the design of a PDA user interface it is important to know how text it is best presented to the user, including the optimal size, typeface and color for the text

The conducted research on Text, where the following guidelines are the result of, can be found in Appendix G.2.

Guidelines for text on active displays:

Font size: For a 240x320 PDA screen, let users choose between a 12 point font size version and an enlarged version with a 14 point font size.

Font type: Prefer sans serif fonts, such as Arial or Helvetica. Upper-case text can be used for titles to attract attention.

Font color: Use dark characters on a light background with at least a contrast ratio of 1:3.

Text length: When using vertical scrolling it is preferred to scroll fluently instead of jumping per line. Another solution for longer sections of text is paging.

7.5 Summary

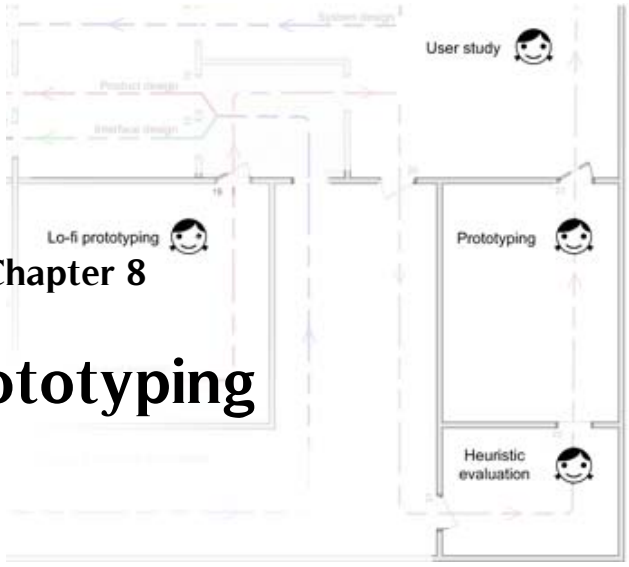
The Multimedia Guide consists of a PDA with a casing, a cord to hang it around the neck, earpieces, a volume control and a Graphical User Interface (GUI). This GUI is PIA, the visitor's Personal Information Assistant. PIA satisfies all types of users by offering layered information, from basic to in-depth. The content of PIA is divided into information categories.

The Guide's functionality is split into basic functions like giving information, helping to navigate and bookmark objects, and extra functions like showing the position of co-visitors, receiving museum notifications, showing the battery state, bookmarks overview, personal museum route, searching for objects, and changing preferences. This is done to keep PIA as simple as possible and to prevent that the basic functions are overshadowed; users who do not have an interest in the extra function will not be bothered by them. The extra functions are placed under the Assistant, which also shows the user's position on an electronic map.

A bookmark tool forms the bridge between the visit and the museum's website. The museum's website contains information about the museum and museum objects, interactive tools, and online library and more, to inform and stimulate visitors of the website to visit the museum. After visiting the museum the visitors get access to the mijnHEIM part of the website where they can view things like their bookmarked objects and the route taken through the museum. The Multimedia Guides will be handed to visitors by museum staff members or volunteers at the Front-desk. At the Front-desk the Guides are stored, recharged, updated and cleaned. To prevent the Guides against being stolen the Front-desk staff members ask for a bank account number, copy of an identification card and signature. A registration terminal, part of the Front-desk, will be used to enter the user's email address, so that users are able to bookmark objects and review them when they visit the museum's website.

The content is very important; it forms the basis of the Virtual Museum. Different guidelines are defined for the content framework with regards to dividing the user's attention between content and surroundings, and the audio and texts files that will be used by the Personal Information Assistant.

The Graphical User Interface of the Multimedia Guide, PIA, is further treated in Chapter 9: Interface and interaction design.



Chapter 8

Prototyping

By prototyping the interface it, can be unveiled if a part of the requirements are met and if all functionality fits in the concept. Every level of the interface needs to be prototyped to be sure that there are no dead ends and that the interface in consistent on every level. Three methods of prototyping have been used consecutively, with each one being more complex to build, but also allowing the tester to test more complex interactions.

Paper prototyping (section 8.1) is the first prototyping tool that has been used. Two evaluations and three user tests have been conducted with five prototyped interface concepts. As stated in the book "Effective Prototyping", paper prototyping is a quick and easy way to get insight in the ease of use, ease of learning and if users like and enjoy working with the interface [27]. When conducting user test with the paper prototypes the tester observes if the test persons can use the interface intuitively and if they can successfully accomplish tasks.

To be able to test more complex interactions, moving elements, and to speed up a singe user test, a new prototyping tool has been developed: digitized paper prototyping (section 8.2). In contrast to existing digital prototype tools, this methods can be used on a PDA. It uses elements from the HTML language, specifically image maps, to turn paper prototypes into simple web pages.

After the digitized prototyping phase, the improved interfaces have been implemented in coded prototypes (section 8.3), after which new user test were conducted including a demonstration at TTH.

8.1 Paper prototypes

The interface design concepts have been drawn by pencil in black and white. This helps to ensure the user's attention during testing and the designer's attention during designing are more on navigational and functional aspects than on the look and feel and the specific icons that are used. A pitfall in paper prototyping is that a smaller font size and detailed icons could be used than will be viewable on the PDA screen, because the resolution of the paper prototypes might be higher than the resolution of a PDA screen. The resolution of most current 3,5" PDAs is 114 px/inch, therefore it is best to print the paper prototypes with this resolution.

Many interface concepts stranded while trying to draw all the possible interface screens. The first four concepts that could be drawn out completely, without leading to dead ends, were stuck to a wall in the office. These concepts have been evaluated by checking them on the guidelines of Appendix H

and by asking a colleague to evaluate them critically. After this first evaluation improvements have been made and, together with one new concept, stuck to the wall for a second evaluation performed by another colleague.

***Figure 8.1**: One of the paper prototyped interface concepts.*

Three people tested the paper prototypes that survived the evaluations. One of the prototypes is displayed in figure 8.1. When asking the persons to take place behind the table with the paper prototypes, the first question was: "How long is this going to take? I have to do more things today." The tests took approximately half an hour. A print of the home page, with the size of a PDA screen, was put down on the table. The test persons were told that the paper is a Multimedia Guide and that the user must imagine walking through a museum with it. Every click on the paper screen was responded to with a new piece of paper, showing a drawing of the page they requested. The test persons made a lot of useful comments on the concepts they tested.

During this project, paper prototyping has been experienced as a tool that is more time consuming that a digital or coded prototype tool. This is because people are not just clicking buttons, but think about actions more. Feedback on the design is more about navigational and functional aspects and the metaphors used for icons than about the look and feel of the design and the particular pictures used for the icons. Also, test persons are speaking about their thoughts more and ask more questions before actually hitting a button, giving the tester more insight in their expectations of the system. In comparison with digital and coded prototyping, people are more willing to comment on the drawn paper interface, because they can see that the interface can be easily adapted.

8.2 Digitized paper prototyping

Digital prototypes can bridge the gap between paper prototypes and coded prototypes, and do not need a persons with programmer skills. The book "Effective prototyping" describes digital interactive prototypes made with programs such as PowerPoint, Word, Excel, Dreamweaver and Photoshop[27]. Unfortunately, all digital prototype tools mentioned in the book are not suitable for a PDA. We could make a digital prototype with, for example, PowerPoint run it on a touchscreen computer and mask parts of the screen that are not used. Reasons for wanting to have digital prototypes on a PDA are that a PDA can be easily brought to a test person, making it easier to find test persons, and that the eventual product will also be a PDA like product.

A solution is found in a new tool, developed by the author, called digitized paper prototyping. To create a digitized paper prototype, the following procedure is used: (1) Scan all pages of the paper prototype and make . png or other images from it. (2) Take note of the coordinates of all buttons, which can be viewed by opening the scans in, for example, Adobe Photoshop or Microsoft Paint. Buttons can be of a rectangle, polygon or circular form. (3) Open a text editor to write a .html page with the code that is displayed in figure 8.2 below. The button coordinates are used to describe the buttons size and position. Every button links to another .html file that contains the .png with the image of the screen to which the button should lead the user to. (4) The folder with all .png and .html files can now be copied to a PDA. Just click on a .html file and it will open in the PDAs browser.

Figure 8.2 shows how the buttons of the drawn interface are linked to the different .html files.

The user can now really interact with the interface; clicking a button causes the PDA to load the new HTML file the button links to.

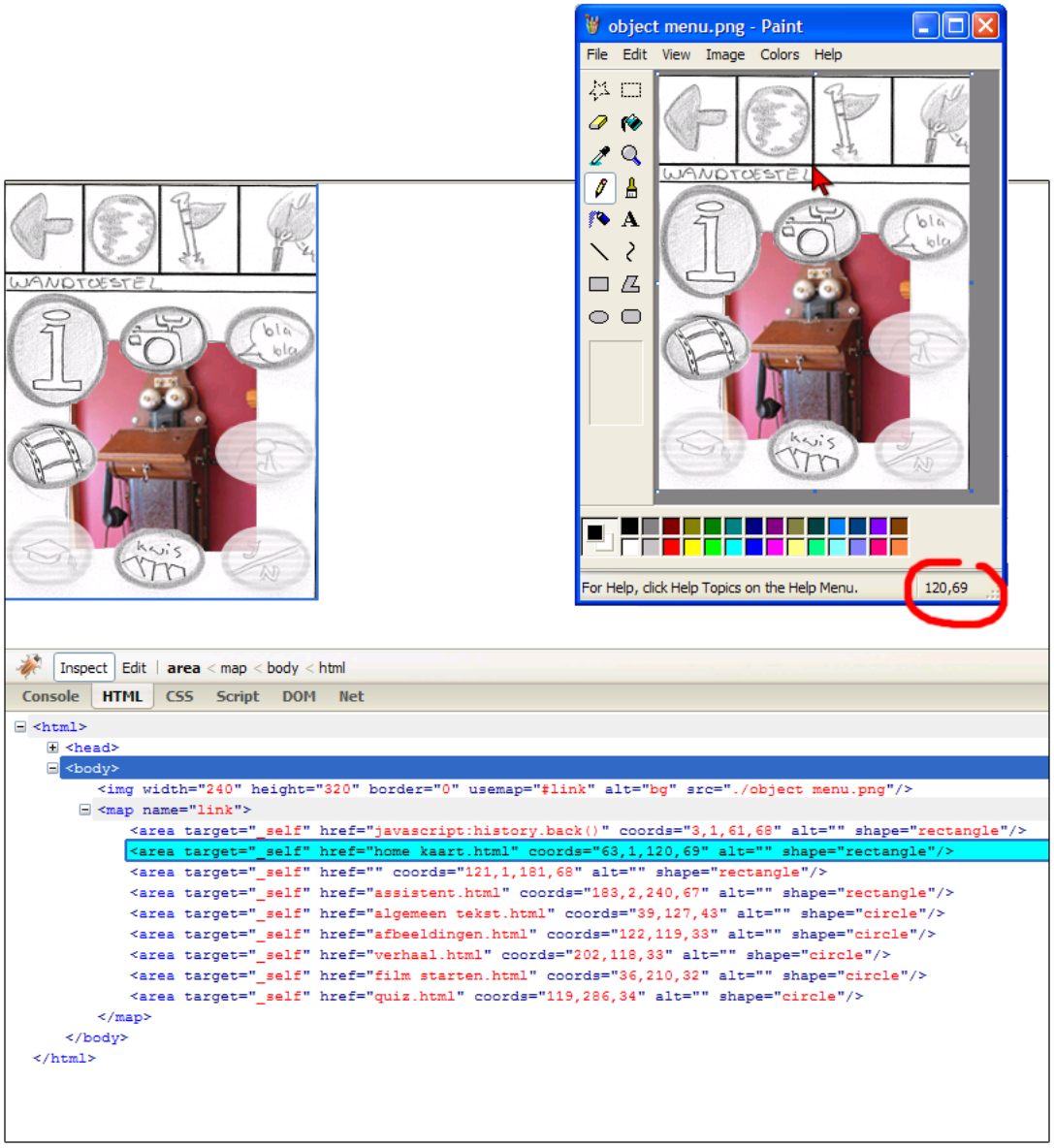


Figure 8.2: *The digitized paper prototype tool.*

With a prototype that a tester can easily take with him and that is always ready, it is far more easily to find test persons than with a paper prototype. The test themselves are also faster because people move trough the interface faster. And because the tester does not have to respond to the each user action by putting a new paper on the table, test persons tend to click more buttons and allow the tester to observe more trial and error moments.

However, digitized paper prototyping also has some minor disadvantages when compared to paper prototyping. Firstly, every minor adjustment in the interface means a page has to be redrawn, scanned and have it's HTML redone. Secondly, the browser on the PDA can react with a windows menu pop-up when a person touches an area on the screen for too long.

Two different interface concepts were translated into digitized paper prototypes, one of them is displayed in figure 8.3, and 14 persons tested one or two of these interfaces. When more advanced ways of entering the different chunks of information about a single museum object needed to be tested it was necessary to code the interface.

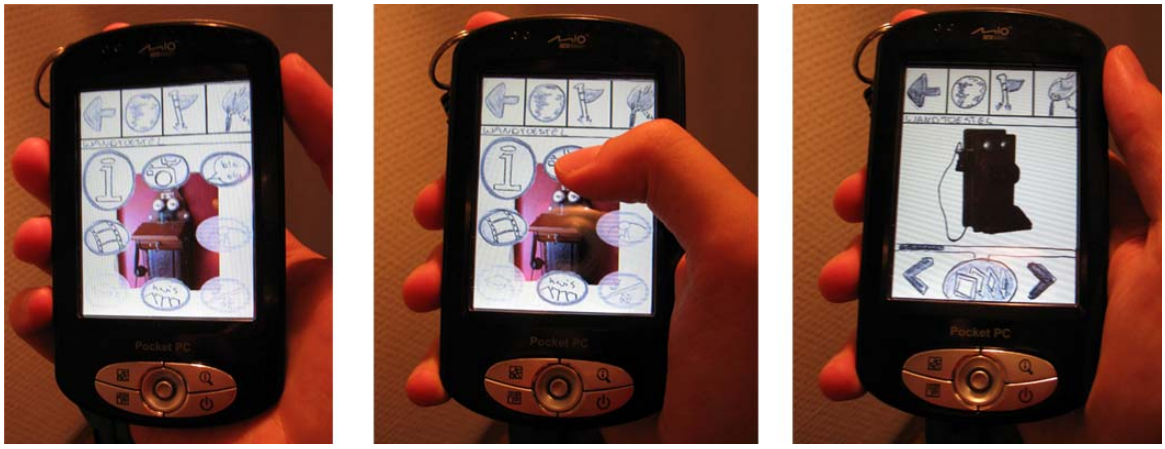


Figure 8.3: *A digitized paper prototype on a PDA.*

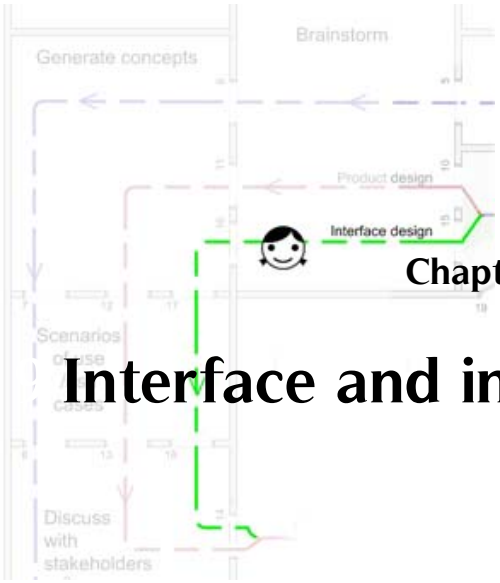
8.3 Coded prototypes

The coded prototypes were made with a combination of web technologies: JavaScript, HTML, CSS and Flash. In the mean time one concept was chosen to test further. Almost all interactions and parts of the interface could be tested with the coded prototypes. Different versions of this concept were programmed, that differed mainly in icons used and in the way the user got access to chunks of information about a single museum object.

Test persons interacted with the coded prototypes more like it is a finished product in comparison to the paper or digitized prototypes. They gave more comments about the attractiveness of the interface and the icons and about the content they read or listen to. The windows menu kept popping up when the user touched the screen too long, just as with the digitized paper prototypes. The last coded prototype has a real working map based interface that shows the user his actual position in the museum, this really amazed people and made them very enthusiastic.

8.4 User tests

Once user tests could be performed with the PDA, testing became much easier and quicker compared to paper models or laptop/desktop computers. People were found to be more willing to participate in the tests. Test persons feel more comfortable and act more natural with a PDA instead of having to sit at a desktop computer or table with pieces of paper, since the PDA can be given to a test person without changing other circumstances. Asking the test person to sit at a table creates a sort of lab surrounding in which people might get the feeling of not being able to satisfy to the supervisors expectation, as already mentioned in section 2.2. By giving test persons the PDA without changing anything else in their surrounding, and telling them that the interface needs to be tested to find flaws in the design, the so-called Hawthorn effect is minimized: This is the effect that people behave different if they know they are evaluated, as mentioned in section 2.2.2 as an aspect researchers should be aware of when performing user tests.



Chapter 9

Interface and interaction design

In order to design a graphical user interface for the Information Assistant which will satisfy the requirements and guidelines, knowledge has to be gathered about general interface guidelines, PDA guidelines and guidelines about icon design. The guidelines will be treated in section 9.1.

These guidelines are used to create interface concepts, treated in section 9.2. The subject of section 9.3 is interaction design. This includes interaction with a touchscreen (9.3.1), which input device to use (9.3.2) and the best way to set up the navigation within the interface (9.3.3).

Section 9.4 determines what behavior and properties should apply to buttons that are operated using a touchscreen, like the size, position and form of the buttons. Using this knowledge, section 9.5 treats the design, including the used metaphors and the behavior, of the following interface elements: the home, back and bookmark button; numberpad; map; help function; and scrolling text.

How the interface should provide feedback is described in section 9.6. The last section (9.7) treats the use of color within the interface and how this can be helpful to make the screen more easily readable outdoors.

9.1 General interface guidelines

The Information Assistant should be usable like a Walk-up-and-use system, defined by Mads Soegaard as: "a system that needs to be so self-explanatory that first-time or one-time users can use the system effectively without any prior introduction/training". Examples are ATMs, ticket machines, public information systems and museum displays [28]. In order to design an Information Assistant that is self-explanatory, it is helpful to have some practical guidelines to start from. Lists with general interface design guidelines are available, but these are mostly not specifically aimed at PDAs, and certainly not at Multimedia Guides.

Handheld device guidelines

Gong and Tarasewich [29] transformed typical desktop guidelines for mobile handheld interfaces. A selection of these guidelines, together with two guidelines adapted from the book 'User interface design and evaluation [30], are used when designing the user interface. These handheld device guidelines can be found in Appendix H.

Interface guidelines for the elderly

The Multimedia guide's target audience is the same as that of an audio guide. Within this audience, the elderly are thought of as representing the most extreme group of users, because they are generally less comfortable with computer-based application. On top of this, eyes, ears and hands work less well, which are important body parts when interacting with small devices. According to Fisk, older adults can be active users of new technologies as long as: (1) the benefits are clear to them; (2) they receive adequate instruction about how to use the system; and (3) the system itself is easy to use [31].

In accordance with the 'Design for All' statement in the book 'Productontwerpen' [32], special attention should be given to the most extreme users and this will probably lead to a better product for all users. User interface guidelines specially aimed at the elderly are freely available, probably because they are often seen as extreme users. The list of interface guidelines for the elderly in Appendix H is a summarization of the guidelines in the book 'Designing for older adults' from Fisk [31].

Icon design

Humans are experts at visually differentiating words from each other. These words can describe the meaning of a button quite accurately [33]. However, because of the lack of screen space on the PDA only words with a maximum of 6-letters can be used, or the word has to be broken up into two six letter parts, as seen figure 9.1.

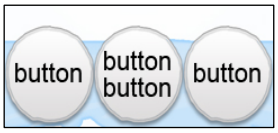


Figure 9.1: *6-letter words, or 12 if they are split, can maximally be used on the touchscreen buttons*

Icons, however, are language independent and take less screen space than a meaningful description in words. They also contribute to the visual attractiveness of the interface [33]. Creating icons is more time consuming than finding words, because finding a meaningful description in words is only the first step of icon design. The combination of icons and tooltips (pop-up labels) cannot be used, because hovering over a button is not possible on a touchscreen PDA.

Icons can in general be split into two groups, graphic symbols and pictographic symbols. Graphic symbols are usually abstract or arbitrary and must be learned, examples are the icons on a CD-player. On PIA this type of icons is used to pause and play an audio or movie fragment. Pictographic symbols are pictures of existing objects. Problems can occur when the user is not familiar with the depicted object [34]. All designed icons have to be tested by possible users in order to be sure they can be used in the application.

The icon design process for the demo user interface was conducted using the ISO 24611 icons design steps, described in the book 'User Interface voor Apparaten' from ir. T.A. ter Hark [35]. These icon design steps can also be found in Appendix H. To assure that the designed icons are effective, they are evaluated with a list of criteria for effective symbols that are adapted from Cushman and Rosenberg 1991, Stone et al 2005 and Raskin 2000 [30, 33, 34].

9.2 Interface concepts

This section treats different interface concepts, using the findings of previous chapters as a starting point. In chapter 7: System design, it has been concluded that PIA should divide information into categories, and that the information should be layered, from basic to in-depth, based on a user's personal preferences. In section 5.3.2 it was concluded that a map based interface is best to use and in section 7.1.2 that a character of an Assistant shows the user's position on the map which can also contain all extra functionalities. The difference between basic function and extra functionality is also explained in section 7.1.2. Furthermore, PIA must contain a bookmark tool, for which guidelines are set up in section 7.1.2, which forms the bridge between a visit to the museum and the museum's website.

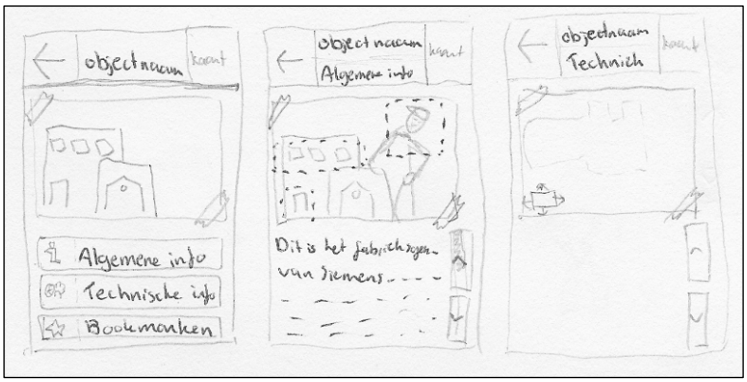


Figure 9.2: *A initial interface concept that fits a PDA screen.*

The first concepts of PIA have been made in the very beginning of the project, like the one in figure 9.2. The interface concepts evolved through evaluations, user tests with prototypes (as described in Chapter 8) and by conducting research described in this report. The different interface concepts and their evolution into the final interface is visualized in this section.

9.2.1 First evaluation

Figure 9.3 below shows three different interface concepts that are the results of an iterative interface concept design process.

The first paper prototyped (PP) user interface (ui) shows a map of the museum with objects that can be clicked to view their information. When an object is opened, a maximum of 8 information categories are shown from which the user can choose, like general information, animation, games and pictures.

Concept PP ui2 shows a start page which refers to the pointer idea of section 5.3.2. The user points the PDA towards a tag (RFID or infrared) to open an object. A picture of the object is shown to verify that it is the same object the user is standing in front of. In the following page, information on the object is given. The texts can be scrolled by dragging over the screen. The other 4 categories can be opened by clicking the corresponding button on the bottom row.

The last interface, PP ui3, also shows a metaphor for a tag scanner. The main difference with PP ui2 is in the top and bottom row of buttons when viewing object information. With the left and right arrows

an information category can be selected. Theoretically, this concept can contain an endless amount of information categories for an object.

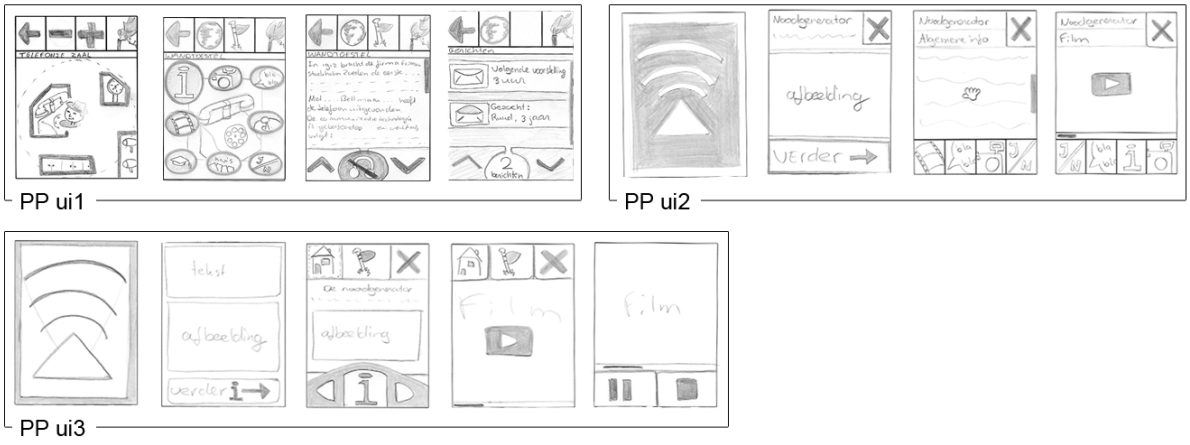


Figure 9.3: *Three different interface concepts that were evaluated*

The three interface concepts do not comply to all guidelines in Appendix H. They do not offer informative feedback, and setting or preferences can not be changed, but in a later stage these aspects can be implemented.

All screen pages of these concepts were printed and attached to a wall. These interfaces have been presented to a colleague, who was asked to evaluate the interfaces critically.

The comments made during the first evaluation can be found in Appendix K. Improvements that were made on interface PP ui1, based on evaluation feedback include:

- Removing the hat of the character on the map, to make it better distinguishable from the Assistant button in the top right corner of the interface;
- Placing the zoom buttons on the bottom row, so it is more clear that they belong to the map and so the top row can stay consistent on every page in the interface;
- The bookmark button is showed on every page to make the interface more consistent, when the bookmark button is inactive it is showed grayed out.

In concept PP ui2 the following improvement were made:

- The behavior of the information categories in the bottom row was changed. Instead of switching position the watched information category icons slides in from the right when a new category is clicked.
- The cross icon in the top right corner was changed to a globe icon, because that is its destination.

In concept PP ui3 the object menu changed in such way that it becomes more clear that the bottom row contains three single buttons which can be clicked. Also the start page of a quiz or a movie is skipped to make the interface less deep.

Another interesting aspect that came up during this evaluation is that it might not be necessary to have a help function; an explanatory movie at the beginning can be enough. A idea that came up was the bookmark status of objects can be indicated on the map.

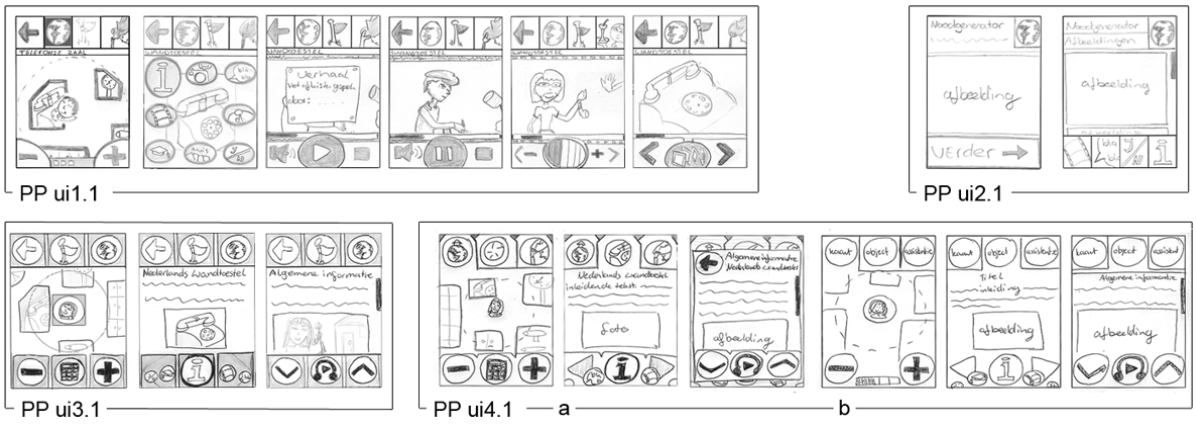


Figure 9.4: *The improved interfaces that were used at the second evaluation and first user test*

9.2.2 Second evaluation

Figure 9.4 shows the improved interface concepts (PP ui1.1, ui2.1, ui3.1) and one new concept, PP ui4.1, which uses tabs and an object menu similar to PP ui3.1. Another person than the one that evaluated the first interface concepts was asked to evaluate the improved concepts.

This evaluation pointed out that the top row of buttons on the home pages (with the map on it) is redundant. Furthermore, the character that shows the user's position must be a very simple figure, so that it is also clear on a low resolution screen. The used metaphor for the bookmark button triggers a discussion: a flag, drawing pin or an envelope could be used.

Textual descriptions might be added to the icons to improve the recognizability. Subtitles could be added to movies, which makes it possible to follow the movie without listening to the audio. In these concepts every piece of content seems to be bookmarkable, while bookmarking just the object would be enough.

Remarks were mostly made on PP ui1.1, the most extended interface concept. The object menu of this concept creates an extra level in the interface; the objects menus of the other interfaces are better in this respect. The interface concept can become more consistent when the information categories 'text' and 'story' use the same interface, instead of a different one. And if the picture's slide show (last picture of PP ui1.1 in figure 9.4) moves up and down instead of left and right, because the texts are also scrolling up and down.

9.2.3 First user tests

User tests are conducted with the paper prototypes ui1.1, 3.1 and 4.1-a. After the second evaluation no changes were made as the comments were minor. PP ui2.1 has not been tested with users because it does not give user the possibility to switch communication channel (for instance from reading texts to listening to audio) and uses interaction gestures that are less intuitive than the others (dragging instead of clicking buttons).

PP ui1.1

The most important comment on interface concept PP ui1.1 is that too much clicks are needed before

receiving information, and that it contains options that the user will not find, because they will not click the Assistant. The object menu in this concept was clear to the test persons in contrast to the object menu's of the other three concepts.

In this paper prototype the test person received a notification from the museum, visualized by a envelope near the character on the map. A comment on the envelope is why it was not bigger to attract more attention, people want to click on it anyway.

PP ui3.1

Interface concept PP ui3.1 shows a numberpad icon on the bottom row of the homepage that leads to a numberpad where object numbers can be entered to access object information. But a numberpad and a calculator look very similar as an icon, causing the icon not to be immediately recognized as a numberpad. One test person was asked to go the quiz of a particular object but he did not understand how the object menu worked.

PP ui4.1-a

Two persons tested PP ui4.1-a. They pointed out that the object menu, to choose an information category from, is not intuitive to use. It only becomes clear after the working has been explained. An improvement that was suggested for this object menu was to get rid of the general information icon, because it seems that the general information is already given when the object is clicked on the map.

The different pieces of information about an object open as a pop-up and are closed by using the back putting. A pop-up is used to create overview, the user can see that the page with the object menu is still open. A comment on these pop-ups during user tests was that it made available screenspace even smaller, and it would be better to use the screen totally.

The headphone with a play icon to start the audio was obvious, but the text scroll buttons on the left and right of the headphone were not clear. One test persons thought they could be used to tune the audio's volume because it looks as if the three button on the bottom row belong together.

The Assistant tab was correctly seen as a place to search for things, like: 'where is the toilet', 'sending messages' and 'look up bookmarked objects'.

Metaphors used

The test persons also made comments on the metaphors that were used in all three paper prototypes to clarify the purpose of the buttons. The words 'blabla' as a metaphor for a story was found too negative: a headphone, mouth, telephone or speaker were given as better metaphors. A filmstrip as a metaphor for a movie was found old fashion, children might not recognize it, a camera was suggested as a better metaphor. The zoom buttons were not clear enough, one of the two test persons thought they were volume buttons, another thought they were used to flip through the pages. A joystick was used for games, but was not recognized. A Playstation controller was mentioned as a better metaphor. As a metaphor for "settings", a drawing of an old machine's setting turn knob was used, but this was not recognized as a 'changing settings' button. Suggested metaphors were: a socket wrench, because most telephone interfaces use that, or a checklist. Furthermore, it is not clear that the flag icon is a button to bookmark an object with. The globe as a metaphor for the map was not clear to everyone,

one thought it could be used to look up a location like in Google Earth. The word 'map' or a picture of a house might be more obvious.

9.2.4 Second user tests

The second user test has been conducted using digitized paper prototypes (see section 8.2 for an explanation of digitized paper prototyping). Paper prototypes ui1.1 and 3.1 have been adjusted according to the feedback gathered in the first user test. No digitized paper prototype was created for PP ui4.1a, because it began to look more and more similar to PP ui3.1.

The digitized prototypes (DP) are displayed in figure 9.5. PP ui1.1 did not need navigational and functional adjustments, but color and some pictures were added (DP ui1). Interface concept 3.1 got a new object menu with new icons. Feedback on the object menus of 3.1, 4.1a and feedback from the evaluations was used to create a new menu which can still accommodate at least five information categories (DP ui2). Also, the top row buttons on the home(map) page has been removed, the globe icon was changed in a map icon, and the flag icon has been replaced with an envelope icon.

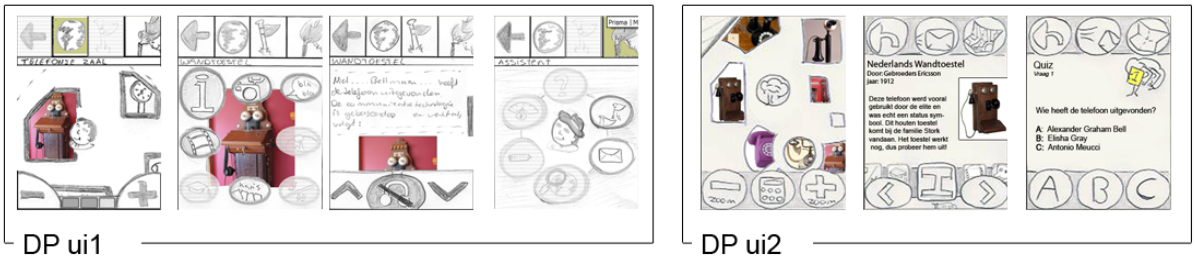


Figure 9.5: *The digitized paper prototypes used during the second user test*

Everyone (14 test persons) used the back button correctly. Some also used the map-button. None of users directly understood the function of the 'bookmark' button. But it became clear when told they could bookmark their favorite objects and would receive more info in an email.

Six persons tested the digitized paper prototype DP ui1 on a PDA. No serious design flaws were unveiled: all test persons were able to work with the interface concept. However, there is room for improvement on:

- the zoom buttons, because it is still not immediately clear where they are for;
- the disabled state feedback, because it is not always noticed that buttons are disabled;
- the stop button in the interface of movies and audio, because test persons tried to go back to the previous page by using this button;
- the globe and flag icon, because their meaning is not obvious;
- the 'switch to audio icon', because it not clear to everyone. One person thought it meant audio was not available.

Eight other persons tested DP ui2. The only element that gave difficulties was the object menu. The method of switching between the different kinds of media was not always clear, most users do not click on the middle button to open the information category.

9.2.5 Third user test

The third user test has been conducted using coded prototypes. In the mean time, it had become clear three buttons on a row is preferred over four, so that 95% of the future users will be able to hit the right button easily (section 9.4.1). Therefore DP ui2 has been transformed into a coded prototype, and DP ui1 has not. All icons were redesigned based on the input from test persons, and a map was made with photographs of objects displayed in the Twents Techniekmuseum HEIM. Information on these objects was placed into categories, and audio fragments were added. For buttons, feedback was added to the active state in addition to the disabled state: buttons gained a yellow border when clicked.

Figure 9.6 shows some screens of the coded prototypes. All of these are based on DP ui2. Coded prototype CP ui1 works the same as DP ui2. In CP ui2 the bookmark and map icon were changed, and in CP ui3 a picture of the numberpad page was added and the object menu was simplified. CP ui3b works the same as ui3 but is designed by a colleague at SIS to test a completely different visual style. CP ui4 is an improvement of CP ui1 and CP ui2 and the more advanced object menu in which more information categories fit. The improvement is that the categories open automatically after a second waiting time, and the names of the categories are displayed underneath the icons. The kids version of CP ui4 uses more playful icons. The last version of the coded interface concepts (CP ui5) uses an expanding object menu, that expands when it is clicked and shows the information categories it contains.

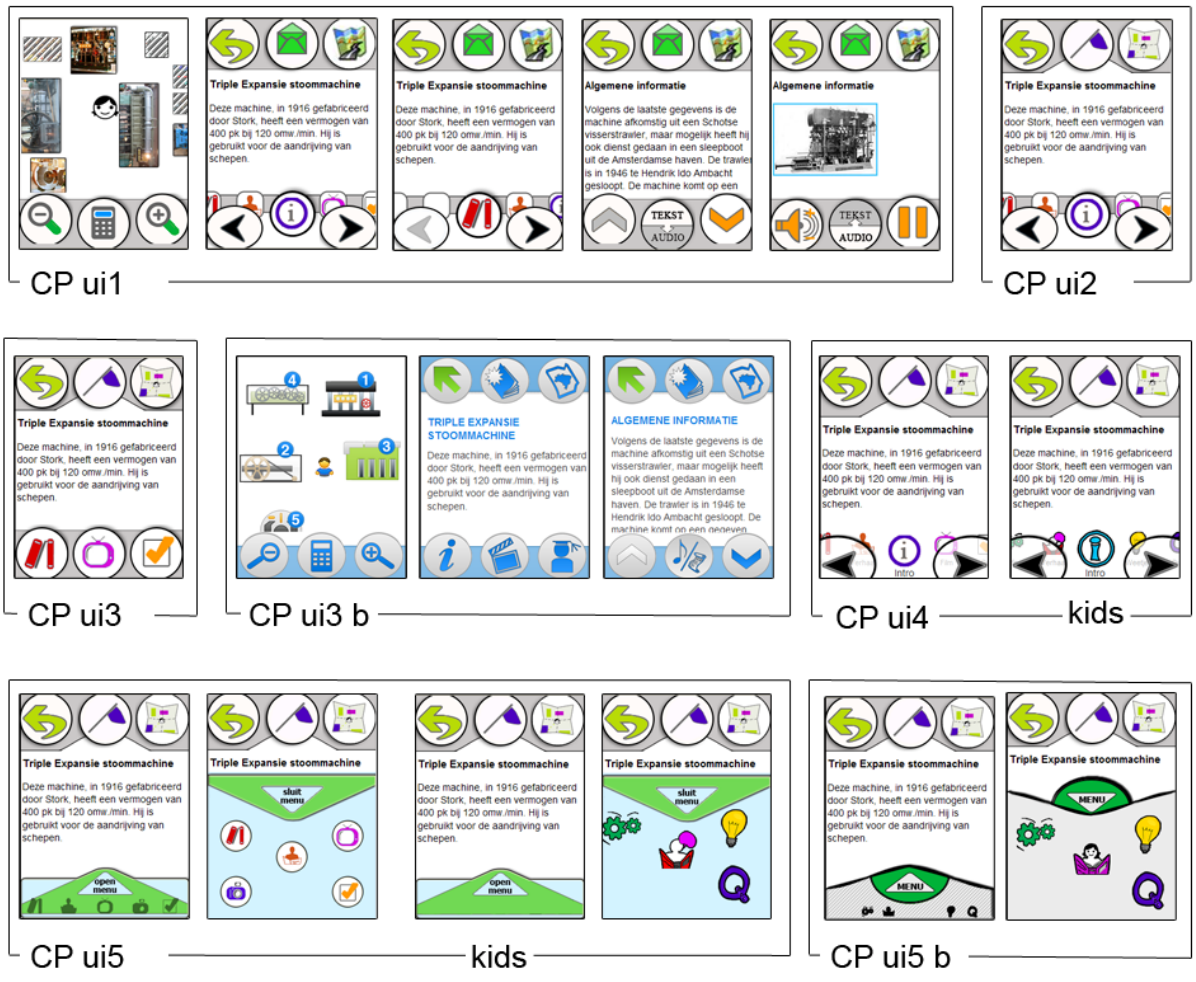


Figure 9.6: *The different coded prototypes*

In total, 28 persons tested one or more of these coded prototype interface concepts. These tests revealed people know how to use the interface and are interested in the possibilities of it. In CP ui1, test persons still had problems with the object menu. Most of them wait for something to happen after clicking one of the arrows. In CP ui4 the object menu was programmed so that it worked exactly as most test persons already expected it to. The object menu as in CP ui3 was experienced as the simplest way to receive different kind of information on an object. In CP ui5 not all test persons noticed that the menu had to be clicked to open and tried to click on the little black pictures that were used to give an indication of what to expect in the menu. But by clicking on those little black pictures, they also triggered the 'open menu' button so the menu expanded anyway.

Because the object menu of CP ui4 has proven to be an improvement over ui1 and ui2, those interface are discontinued. CP ui3 is the most simple interface, and no difficulties surfaced with opening object information. A disadvantage of this object menu is that is can only contain three information categories. In CP ui5 the difficulty is to make clear that the object menu has to be opened before selecting an information category. An advantage of CP ui3 over CP ui4 and ui5 is that it requires less click actions to receive object information and does not require explanation, making it better fit with the guidelines from section 9.1. The object menu of CP ui3 Is therefore the one that will be used at TTH. The disadvantage that it can only contain three information categories not severe, as more information is not available at the moment. But for the 'greedy users' who want in-depth information on everything, as described in section 7.1.2., it must be possible to receive all available Multimedia Guide information when available. In that case the object menu could be switched to CP ui4 or CP ui5. The workings of the specific object menu can be explained it the help function or introduction movie, as treated in section 9.5.4.

For the demonstration in TTH the concept of CP ui3 is used. The demonstration interface is graphically styled to give it a visually balanced appearance. More information about the particular icons for the back, bookmark and home button can be found in section 9.5.1 and about the numberpad and map in section 9.5.2 and 9.5.3.

The demonstration interface, that is a final product of this project, is presented below in figure 9.7.

Figure 9.7: *The demonstration interface*

9.3 Interaction design

In this section the different methods of interacting with a touchscreen are treated and a selection strategy for PIA is chosen. The choice for an input device is explained and some important aspect with regard to navigation in the interface are treated which results in two guidelines.

9.3.1 Interacting with the touchscreen

On a touchscreen PDA we can tap once, tap and hold, and drag. That means there are three possible forms of interaction with the touchscreen. Each could have its own function. But, how do we make this clear to the user?

The most intuitive way for a user interact to with the PDA is simply press the button he wants to use. The duration for which the user touches the screen does not need to have an influence. In teaching older people to use a computer, the author observed that learning to double click is very hard because the timing needs to be very accurate. Just clicking a button or link is (except for the positioning) not a problem because the timing is not so strict. A usability study conducted by the Indiana University Computer Science Department showed that there are no major differences in performance of PDA tasks between elderly (75-85 years) and younger (25-30 years) people. The tasks they tested are comparable to the task the users will come across when using PIA [36]. Design guidelines for elderly, however, are still relevant because they are not only about clicking buttons and scanning tags but also about aspects like navigation, organization and text size.

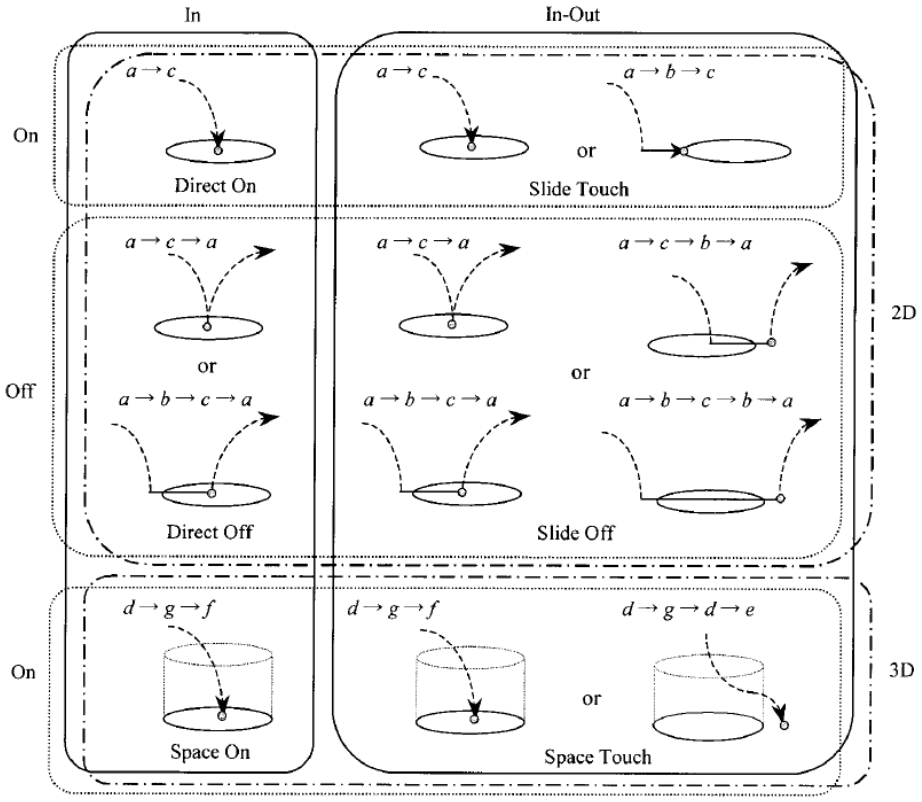


Figure 9.8: *Six groups of selection strategies [1].*

By default, a button on the touchscreen is activated when the land and release take place on the same button. If this is not the case, the button is not activated. Different scenarios are illustrated in figure 9.8. The default behavior of PDA touchscreen buttons is similar to the first picture of the second row: the 'Direct Off' method (a -> c -> a). Because the interface will be implemented in a browser, JavaScript can be used to change the behavior to activating a button as soon as it is touched. This is comparable to the 'Direct On' method. Slipping of the button has no influence, which makes the chance of a success larger. 'Direct On', also called 'mouse down', is also faster than 'Direct Off' because the application does not have to wait until the user takes his finger or stylus off the screen.

The demo version of PIA operates best when viewed in the Opera Mobile browser. Compared to other PDA browsers, it offers the best support for web standards like JavaScript and CSS. A disadvantage is that in this browser the 'right mouse click menu' cannot be turned off. That means that a small menu shows up when the user holds his finger on the screen too long. This happened a lot during testing and is very annoying. The expectation is that with the new Firefox mobile browser (Open Source) currently in development, this 'right mouse click' event can be removed. In that case, the time a button is pressed is of no influence anymore. This will simplify the interaction with the PDA.

Dragging can also be used on PIA, for example to drag the map. The interaction has to stay consistent so when the user touches an object on the map, this object will open. But when the user touches the screen around an object, he is able to drag the map.

9.3.2 Input device

In his book, Fisk suggests to use input devices that are as direct as possible to perform point-and-click operations, because they tend to be more intuitive and natural to use [31]. The 7^{th} boundary condition of Chapter 4 states that the device should be controllable by finger touch rather than stylus. In comparison with a stylus a finger is also less sensitive to theft, getting lost and breakage.

A disadvantage of the finger as input device is the issue of finger-resolution. A fingertip has a relatively large area compared to a mouse or stylus, causing it to be less accurate to specify a particular pixel [37]. When the finger is above the pixel and lands, it obscures the pixel it touches, which makes it harder to hit. The buttons on the PDA should therefore be bigger when the finger is used as input-device.

9.3.3 Navigation

The target audience of PIA includes older adults; the guidelines for designing PIA have to take this into account. Older adults frequently miss overview in a computer application; they get lost during navigation and revisit previously seen pages more often. They are also more fixated on the start page and often go back to this page before starting a new task compared to younger adults [31].

Wanting to go back to the start page after fulfilling a task is also something that came up very often during the different user tests that were conducted with PIA. The start page is the place in the interface that gives the users a feeling of safety; therefore it's probably often called 'home'.

This results in the following **guidelines**:

- The interface must have a unambiguous start page.
- It must be clear which pages have been visited.

In the user interface of PIA the map is the start page, showing the position of the user and giving access to objects.

Depth versus breadth of menu structures

What is the optimal relation between depth and breadth of a museum guide menu structure? Broad menu structures reduce the demands on people's memory but increase the need for visual scanning or scrolling. Menus with a deeper structure may improve the organization of the information but also increase the likelihood that users will get lost in the system or have to backtrack to an earlier level [31].

Figure 9.9 shows the menu structure of the final interface: PIA. Level zero is the map or numberpad, level 1 is the introduction page of an object which contains the object menu, or the introduction page of the Assistant. The second and last level contains the actual information, on which the user can switch between reading and listening without going a level deeper.

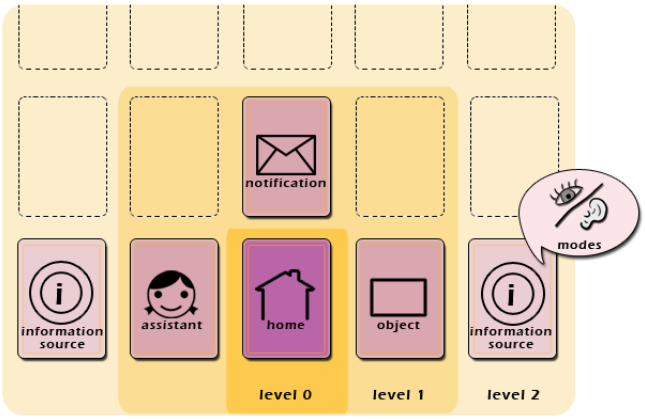


Figure 9.9: *A visualization of PIA's menu structure.*

9.4 Touchscreen buttons

In this section the size, position and form of the touchscreen buttons is determined. With regard to size, no research on the minimum and optimal size for buttons operated by finger was found. A test has been performed to calculate the minimum touchscreen button size. The second part of this section describes how to position the buttons on the screen so they can be easily reached and the user can see what he is doing on the screen. The last part contains a recommendation for the form of the touchscreen buttons.

9.4.1 Button size

To make sure most users will be able to easily use the software buttons with their fingers, a minimum size for the buttons has to be established. When the minimum button size is known, and thereby the amount of buttons that fit on the screen, this figure can be used as a criterion to determine if a device or screen meets the requirements for the interface. The test results, used formulas and the calculations can be found in Appendix E.

According to Cushman and Rosenberg, keyboard keys should be at least 13x13 mm with an interkey spacing of 6,5 mm [34]. Fisk propagates a software keyboard key size of 10x14 mm with a interkey of 9 mm [31]. These suggested sizes are for hardware buttons, not software buttons. An advantage of a touchscreen is that it can react (if programmed to do so) to the first touch, so it reacts on the first part of the finger that hits the screen.

A human fingertip has a rounded form, so the area that hits the screen first is smaller than the total fingertip breadth, as can be seen in figure 9.10. Even when the forefinger rests on the screen completely, the touched area is not as wide as the forefinger itself. Therefore it is important to know which part of the forefinger breadth represents a fingerprint. The fingerprint is the part of the finger that is placed on the screen when someone touches a button. Because more and more youngsters (sms-generation) use their thumbs for pushing buttons, the thumb is also included in the calculation of the minimum touchscreen button size.

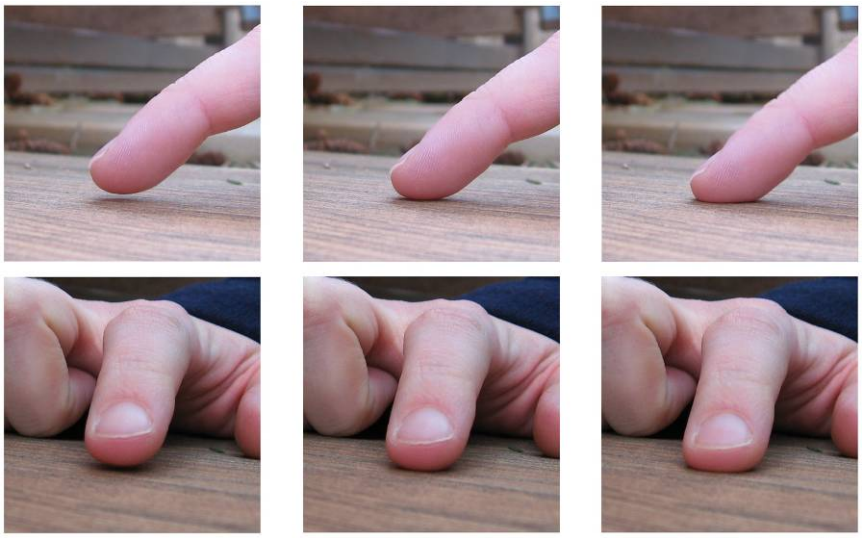


Figure 9.10: *The touch area is smaller than the forefinger breadth.*

To calculate the minimum button size, the anthropometric dataset 'Dutch adults', Population 'DINED 2004 (20-60 years)' from the Delft University of Technology was used. [38] To prevent the buttons from having to be a lot larger to satisfy just a small amount of users, it is found acceptable that touching the buttons will be a little bit harder for 5 percent of the adults. Therefore, calculations were based on the P95 forefinger and the P95 thumb breadth of the adult population. The DINED dataset

gives the date for males and females, to translate these values to the whole adult population it is assumed 50 percent of the users will be male and 50 percent will be female.

The fingerprint area, the part of the forefinger breadth that is used to activate a touchscreen button, is not a measurement in the DINED dataset. To get an indication of the fingerprint area to forefinger breath ratio a test has been conducted. For this test the fingerprint of one male and one female were measured (multiple times), and compared with their forefinger breadth. The same was done for the thumb. The indication from this test is that the finger or thumb print area is approximately 65 percent of the breadth. That means that the P95 forefinger-print and de P95 thumb-print are 65% of P95 forefinger breadth and P95 thumb breadth. This results in a $P95_{\text{forefinger breadth-touch}}$: 13 mm and $P95_{\text{thumb breadth-touch}}$: 17 mm. Calculations can be found in Appendix E.

Using these figures, the amount of buttons that fit on the touchscreen can be calculated for the PDAs used during the demonstration. The screen size of these PDAs is either 7,1x5,3 cm (3,5 inch diagonal) or 5,3x4,7 cm (2,8 inch diagonal). To assure that 95 percent of the adult users will be able to touch the buttons on these screens easily, at most 3 buttons horizontally or 4 buttons vertically will be used. Users that use their thumb as input device can have some trouble on the 2,8 inch screen. This can be easily solved by using the forefinger instead of the thumb. In Appendix E a table can be found with the percentages of adults that will be able to easily activate the buttons plotted against the amount of buttons on a 3,5 or 2,8 inch screen.

Some other factors also influence the minimal button size on a touchscreen. For example: the difficulty of placing the finger on a small button when the finger itself is blocking the view, and the fact that a touchscreen button is not tangible like on a TV-remote control. But on the other hand, the part of the finger that hits a touchscreen button first is smaller that the 65% of the forefinger breadth.

9.4.2 Position of the buttons

According to the minimum button size, calculated in the section above, 12 buttons fit on a PDA screen in landscape or portrait view. Apart from buttons, the screen should also show content, like text and movies. Placing the buttons next to the screen border has the benefit of giving the user some margin and guidance to hit the button properly. Also, placing the buttons in the middle of the screen makes it very hard to place content, as this would mean it has to be wrapped around buttons.

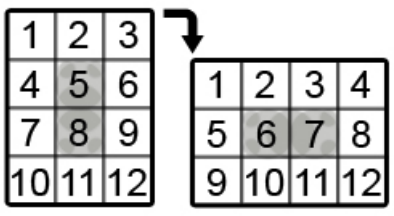


Figure 9.11: *Position of the buttons in portrait and landscape view*

Some buttons on the screen can be used while the user is reading or looking at the content. Right-handed users could easily scroll text using scroll buttons on the right side of the screen. Left handed users will block their own view at the screen while doing this, because they prefer to use their

dominant hand. Left handed users represent 10 percent of the Western population [39]. The bottom row is easy to reach for both, left and right handed, without occluding the content they are watching.

During the design process, the portrait view was preferred. In this view mode the distinction between the navigational elements, like back and home, and buttons belonging to an object or piece of content was more distinct. So the best place to put buttons is on number 1,2,3 and 10,11,12 in portrait view (see figure 9.11).

9.4.3 Button shape

What should be the shape of a button designed to be touched with a finger? The design of the button has to help the user to aim the finger at the middle of a button, in order to have the best chance of actually hitting it. A rounded shape will probably lead a user's finger best, since this is the shape of the finger when touching the screen. In the middle of this rounded form an icon will be placed as being the 'rose'.

9.5 Interface elements

In this section, the design and behavior of navigational elements of the Multimedia Guide interface are treated. The most important buttons, namely the home, back and bookmark button are described in section 9.5.1. The numberpad and map, which are both used to access object information, are described in this section 9.5.2 and 9.5.3. The help function is described in 9.5.4 and in section 9.5.5 a visual aid is described to support the scrolling text used in the interface.

9.5.1 Buttons

A button is a space in the interface that leads to the execution of an action when touched by the user. The function of a button can be indicated by an icon (a graphic representation), a word (a textual representation) or a combination of an icon and a word. A metaphor can be very powerful, but only if it matches the users' experience of the world [30]. It is important that the user understands what a button stands for and what it does.

The design of the home, back and bookmark button is described in this section. Important guidelines for designing buttons and icons are summarized in section 9.1. According to those guidelines the buttons should have defined borders, the icons should have high contrast with the background colors, and the icons should be meaningful and representative of the concepts they are meant to convey. This last aspect will be tested during user studies.

The Icon design process

The icons designed for interface for the demonstration at TTH are designed according to the steps described by T.A. ter Hark [35], which can be found in Appendix H.

First a clear description of the icon is given and icons expressing this description are searched for. Based the metaphors found in existing icons, icons are designed that match the visual style of the

interface. Designed icons are kept simple, not too many thin lines are used, and are shown to people asking them what they think the icons mean. When designing the icons it should be kept in mind that the icons can be viewed from multiple angles, because the PDA can easily be turned around 90 or 180 degrees. The icons are designed on a larger canvas than necessary and reduced in size at a later stage, because higher resolution icons might be needed in the future.

The required height of an icon can be calculated by dividing the viewing distance by 100. During an icon size test of Moor et al, users held the PDA 16" away on average [36]. So in the case of the Multimedia Guide, this means icons must be at least 4,1 mm high.

The criteria for effective symbols mentioned in section 9.1, which can be found in Appendix H, will also be used to evaluate the ultimate icons.

Home button

The home or map button always allows the user to go back to the start page immediately. We choose to use a home button in addition to a back button, because this allows users to go the start page in one click, no matter how deep the interface's menu structure is. Although the hierarchy is in this case only two levels deep, this is not always obvious to the user, so it is still possible to feel lost in the application. When a user doesn't know where he is in the application and wants to go back to a familiar place, he can always press the home button. This will prevent the feeling of being lost or stuck at some place in the application.

Figure 9.12: *The home icons used in the different interface concepts*

Early sketches of the interface used a map icon as home/map button. During paper prototyping and digitized prototyping the Dutch word for map, kaart, was used as well as drawings of paper maps, globes, houses, crosses and a graphic symbol for the 'pointer' idea. With the 'pointer' concept the user uses the PDA as a remote control, aiming it in the direction of the museum object to receive information. These different icons can be viewed in figure 9.12.

During testing it was found that the **globe** as a home icon was not interpreted as a button that leads the user to the beginning page, to the map. Below are some remarks test persons made during paper and digitized prototyping.

> *Man, 54 years old: "When I click on that globe I get to see where Stockholm is? The text already mentions that Stockholm is situated in Sweden, so the globe would only be useful for very dumb persons. Yes, I think the globe is like Google Earth. It is not obvious that the globe icon leads to the beginning page, it might be obvious if the text 'map', or 'back to the beginning page' would stand on that place. An icon of a house might also be clear. The back button can also bring me to the map, so you could make a double arrow of it that would stands for extra fast."*
>
> *Woman, 25 years old: "With the globe I will probably go on the internet."*

Most test persons do understand the meaning of the **map** icons.

> *Man, 58 years old: "What does the button in the upper right corner do?"*
>
> *He then clicks on it and sees the map appear. Now he understand where the button is for and that the icon represents a map.*
>
> *Woman, 50 years old on seeing the map icon: " Ah, back home again. But with that arrow I also go back? Oh with the map button I go all the way back to the map and with the other one I only go one step back."*

Demonstration interface

For the demonstration interface, the icons have been redesigned according to the guidelines presented in section 9.1. For the home button a clear description was formulated for the three possible scenarios: go to the map, go to the home page and go back to the numberpad. Existing icons represent these as paper maps, houses and a calculator. The icons were drawn with a pen table in high resolution with minimum lines and details. The designed home icons were used in different versions of the demonstration interface and tested by users.

> *Man, 15 years old: "An arrow for back, a floppy disk for saving and a treasure map also for saving. I know that with the treasure map I go to the map, back to the beginning. But other people that do not know that might have difficulties with this icon. On a treasure map you mark the place of a treasure to remember where it is, so actually that is also saving."*
>
> *The map icons of CP ui3b and CP ui5b--kids are shown to him, the abstract icon of CP ui3b is not clear, the one of CP ui5b-kids is found to be most obvious (this is the 7th map icon in figure 9.12).*

During user tests at TTH the home, numberpad and map icons were used. One persons remarked that the numberpad is confusing because it looks like a calculator, something that also came up during earlier user tests. The numberpad icon does not comply to all criteria for effective symbols mentioned in section 9.1, which can be found in Appendix H. It is in conflict with the existing metaphor of a calculator (2nd criteria) and is not easily recognized and understood by everyone (4th criteria). The final home and map button comply to all of the criteria for effective symbols and can therefore both be

used on PIA. The home button can always be used, the map button only when location based services are used in the museum to calculate the user's position.

Back button

The back button is something that internet users are used to. This is an essential button in the interface. It is also a button that users use when they don't know which action to take next. The back button provides an undo function, making the interface tolerant of user errors [30].

As far as we know the back icon is always drawn as an arrow, pointing to the left side of the screen.

Figure 9.13: *The back icons used in the different interface concepts*

All nine icons in figure 9.13 above look alike, although the style differs to fit with the other icons, like the bookmark and home button. The meaning of the back button was clear to all test persons and was used by everyone.

> *Man, 23 years old: "With the back button I will go one screen back."*
>
> *A woman, 38 years old looks at a movie for a while and then wants to go back,but does not know how to do that immediately. After looking at the screen for a while she notices the back button and clicks on it.*

Demonstration interface

For PIA the last icon of figure 9.12 is designed, taking the same procedure as with the home button. The icon was tested during the demonstration and passed the test easily, as it complies to all criteria for effective symbols.

The bookmark button

The bookmark button can be used when the user finds an object interesting and would like to learn more about it, or would like to review the object later. The function of the bookmark button should be instantly recognizable to the user by its appearance. As mentioned in section 9.1 this can be accomplished by using an icon, a word or a combination of an icon and a word.

The bookmark metaphor

The term used in research papers about multimedia guides for the above described function is bookmark. But the term 'bookmark' does not inform the user about the possibility to review the bookmarked objects online. Additionally, it is a difficult word for non-native English speakers if they have never encountered it before [23].

According to Filippini-Fantoni and Bowen, visitors think about sending an e-mail when wanting to receive information of interest at home. Most visitors are familiar with this term and understand what it does. The Tate Modern Multimedia Tour uses the term 'e-mail information home' for the bookmarking tool which is fairly self-explanatory [23]. However, due to the small space available for the bookmark button, 'e-mail information home' does not fit. Translating the sentence into an icon might be a possibility. The Antwerp museum Vleeshuis uses an envelope to indicate the bookmark button. When users touch the button they can type a message and then send it, very similar to sending an email.

The user might think that an email is sent to his inbox when he presses the bookmark button while in fact the following steps take place:

1. The number of the current object is added to a list of bookmarked objects.
2. The bookmark list is linked to the users e-mail address.
3. After the visit, the Museum System sends an email with login information to this email address.
4. The user can log in on mijn.museum.nl and review bookmarked objects for more information.

The impression that every bookmarked object means a new email message in the inbox might stop the user from using the bookmark tool because (as described in section 7.1.2) the user might be afraid of junk e-mail and information overload.

Another problem with the e-mail/envelope metaphor is that in the designed PIA interface the envelope is already used for messages sent by the museum.

Bookmark survey

In order to get some insight into the mental model (how users think a certain mechanism works in the real world) of possible users and what metaphor could best be used for the icon, a bookmark survey was created. A screenshot of this online survey can be found in Appendix F. The link to the online survey has been sent to people in different age groups and with different levels of computer experience (diagram that visualize this data can be found in Appendix F). The survey starts with an

introduction about the graduation assignment, and described a scenario with text and illustrations. The last part of the scenario, which can be seen in figure 9.14, contains the actual problem statement:

You are very impressed by the "Triple expansion steam engine", the object you are standing for, and want to read the associated information again when you get home. To ensure that your assistant remembers this, you push the button with the question mark. Which icon do you expect on the spot of the question mark?

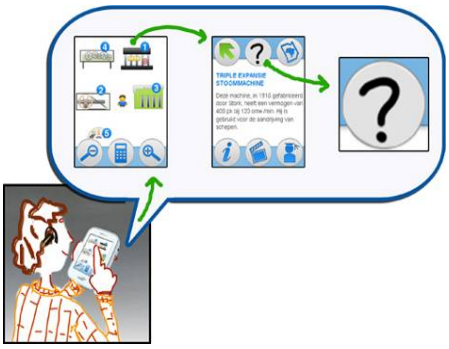


Figure 9.14: *Last part of the bookmark scenario, used in the bookmark survey.*

The participants of the survey were then presented with a choice from the following 16 pairs of icons displayed in figure 9.15. For each pair, the top icon represents the unbookmarked state, while the bottom one is the bookmarked state. Participants were allowed to choose more than one.

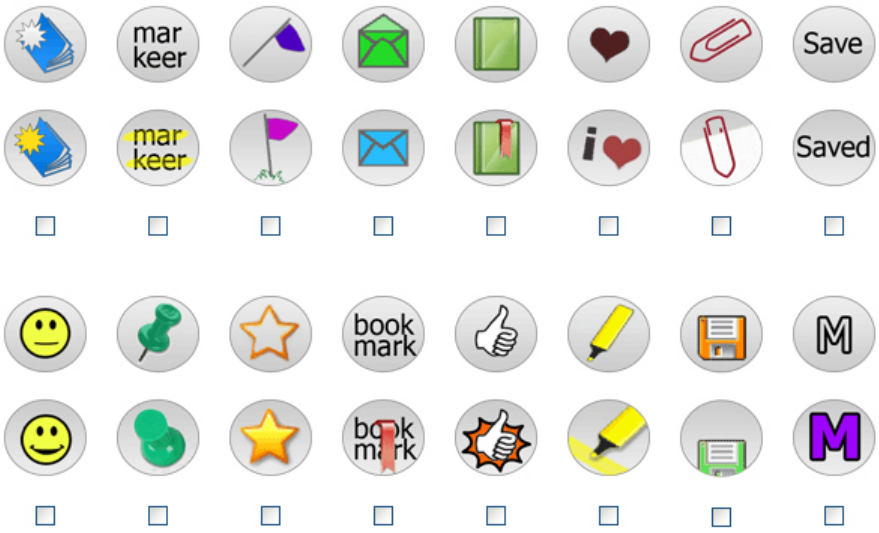


Figure 9.15: *Which icon(s) would you expect on the location of the question mark?*

In the next question, participants were asked for their reason for choosing these icons (or this icon). Finally they were asked for name, age, weekly computing time and experience with PDA's.

188 people participated in the survey, with ages ranging from 10 to 78 and an average age of 35. Together they marked a total of 303 icons.

Results

The statistic results from the bookmark survey can be found in Appendix F together with the bookmark survey analysis.

In the current interface, icons are primarily used because they are language independent, making the interface more attractive and emphasizing the difference between navigational interface and presented content. As a result of the analysis, which can be found in Appendix F, the floppy icon is the best candidate to use in the Demo interface. But the floppy disk icon used in the bookmark survey has room for improvement. Special attention has to be given to the use of color, the difference between the normal state and the bookmarked state and the clarity of the icon.

The new bookmark icon, based on the results of the bookmark survey is presented in figure 9.16. This new icon is tested during the demonstration of the Multimedia Guide.

Figure 9.16: *The icon that resulted from the bookmark survey and the adjusted icon.*

Icon adjustments

The color of the floppy disk is blue instead of orange. This has three reasons:

- The color orange can have an alarming association, like orange traffic lights.
- To give the interface a calmer look, one color (blue) is used for most of the icons.
- To visually group the bookmark icon with the information source buttons in the bottom row which belong to the object, the same color is used for all of these icons.

The idea of a floppy disk with a checkmark is also mentioned by a person in the bookmark survey. The checkmark is added to the picture when the bookmark button is in bookmarked state. This achieves a difference between the normal and the bookmarked state that is much bigger than it is for the floppy disk icon used in the bookmark survey. Making it easier to distinguish the icons from each other (3rd criteria from effective symbols). The checkmark can be seen as a visualization of "good", "okay", "checked" and "I agree". The green color, as mentioned in section 9.7 (color and contrast) refers to: active, enabled, normal, on, on-line and run. It is therefore an excellent color for the bookmarked state of the bookmark button.

The bookmark button complies to all criteria for effective symbols, this list can be found in Appendix H.

9.5.2 Numberpad

The numberpad is used to enter object numbers. The numbers on the numberpad can be organized like on a telephone or like on a calculator. Both allow numbers to be entered, but the button lay-outs are different.

The Multimedia Guides in the CODA museum and Museum Vleeshuis also use a numberpad. The lay-out of these numberpads (figure 9.17) are the same as the arrangement of the numbers on a telephone.

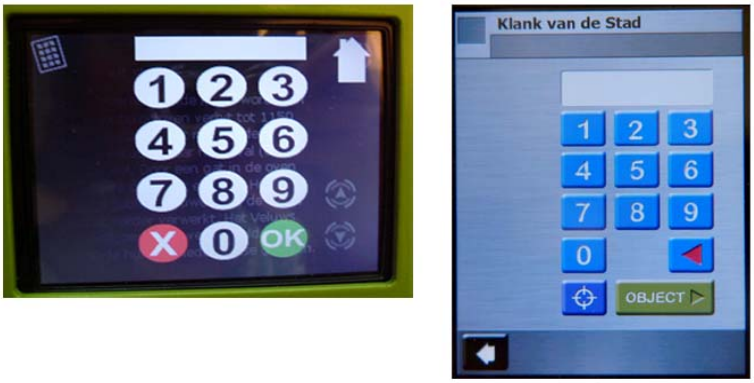


Figure 9.17: *The numberpads used in the CODA museum and Museum Vleeshuis.*

Nowadays, people use telephones more often than calculators and are probably more familiar with the telephone lay-out. Typing a number on a Multimedia Guide to access object information is also more familiar to interacting with a telephone than with a calculator. The telephone style numberpad is therefore chosen [35].

Figure 9.18: *Different numberpad screen from different interface concepts.*

Figure 9.18 shows the different numberpad screens used in the design process. The numberpad consists of the following elements: an input field, number buttons 0-9, OK button and a backspace button. It has to be clear that the buttons are clickable and the input field is not. The numberpad can be reached through a button on the home page or in place of the homepage. The main difference between the two is the need of a back or home button when the numberpad is reached through a button on the home page. When the numberpad is the homepage, as the third one of figure 9.18, there is no need for a back button. This set up, with the numberpad as home page, can be used if no location based techniques is used in a museum, when the only way to reach object information is to enter the number on the Multimedia Guide.

Feedback

The interface must give the user feedback on the numbers he enters. When the user enters a non existing object number the interface must explain to the user that there is no information for that number and give the user the opportunity to enter another number. The feedback message must be polite, so the user does not get the feeling of doing something wrong. So no messages like 'error' or 'wrong number', but messages like 'sorry, object can not be found' or 'sorry, information on this number is not available'. This message can be placed in the input field where it would normally read a message like 'Fill in the object number and click on v'. When a number button is touched, this message is replaced with the entered number. When a non existing number is entered, the message 'object can not be found' appears in red to attract the user's attention.

The use of the numberpad will be explained in the introduction movie. This way the users have seen the procedure already one time and will probably be more self-confident when using it themselves.

9.5.3 Map

To be able to click objects on the map, the objects have to be displayed in a way users will recognize them. Important restrictions are the size and resolution of the PDA screens. In the first prototypes maps were already used, as displayed in figure 9.19.

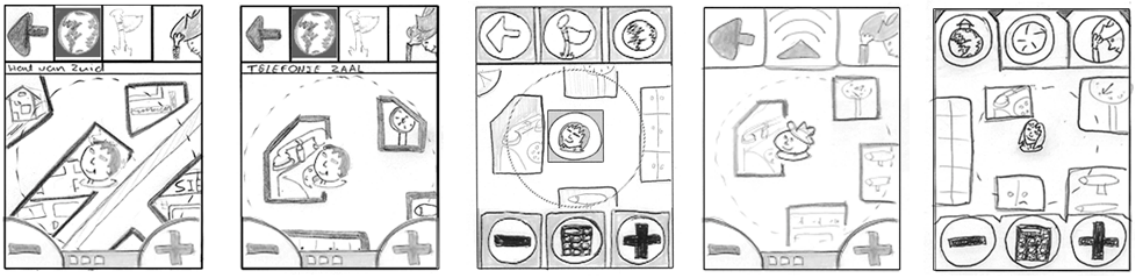


Figure 9.19: *The different maps as used in the paper prototypes.*

During paper prototyping all users recognized the map with objects on it. Below is one remark a test person made during a paper prototyping test.

Man, 54 years old: When I want to know something about the telephone I click on the telephone.

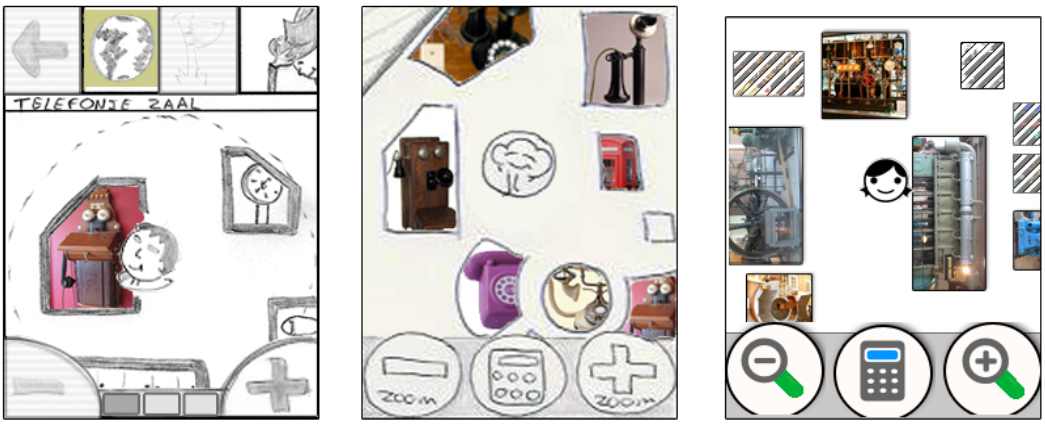


Figure 9.20: *The maps that were used in the digitized paper prototypes and the first coded prototype.*

In the two digitized prototypes, which can be seen in figure 9.20, pictures of objects were added to the maps. Again all test persons could work with the map. But, just as with the paper prototypes, the test persons were not actually in the museum and the objects on the map were not related to objects in the real museum. So it could not be tested if people recognized the objects or if they could orientate themselves using the map. Only the interaction with the interface itself was tested. Based on the user tests (14 persons tested the paper or digitized prototypes) it can be concluded that people recognize the home page as being a map with object on it and understand how to interact with it.

> *Woman, 19 years old: Does the museum really look this way? It looks a bit messy, not very organized. And I suppose such a telephone cell is in real life much bigger than a telephone. On the map the telephone cell is smaller than the telephones (DP ui2 in figure 9.20).*

The interface CP ui1 , which can be seen in figure 9.20, is the first one with a map that corresponds to the actual map of TTH. The objects from which no information was available were showed disabled (shaded). Remarks made by test persons were about those disabled/shaded objects and about how to interact with the map.

> *Woman, 25 years old: I. asks if she is the character she sees on the map, she tries to drag the character towards an object. She understand how the product works, but she says that if she only gets the PDA like this she is inclined to let the character walk on the screen. In the map, I. clicks on a shaded object. The screen does not give a reaction so she clicks again.*
>
> *Man, 13 years old: R. clicks on a shaded object on the map, nothing happens. He asks if that object is perhaps not included.*

As with all grayed out or shaded objects and buttons, users still try to click them. Although they mostly understand the disabled state, they click on the object or button just to be sure. Another interesting aspect observed during user testing was that two persons tried to drag the character around the map. None of the 17 persons during paper and digitized prototyping tried to do that. It might be a coincidence or because the interface looks more real people start to explore more.

Illustrations versus photographs

A test was conducted to find out how the object could be presented best; with photographs or Illustrations.

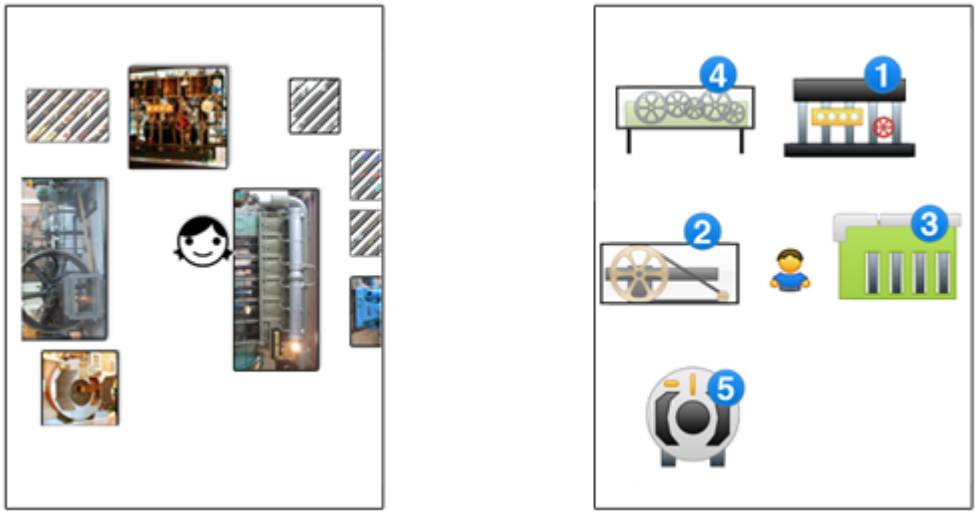


Figure 9.21: *The two different maps with a PDA screens resolution, used during the test.*

During paper prototyping and digitized prototyping, maps both used pencil drawn objects and photographed objects. To investigate which way of presenting the objects is better, photographs or illustration, a test was conducted at the TTH. For this purpose, two maps were created, one with photographs on it and one with illustrations representing the objects (see figure 9.21). These maps were printed with the resolution of the PDA screen (114 px/inch) and presented to test persons on the same size as they would have been shown on the PDA (2,8 x 2,1 inch). The test persons received a paper map with either illustrations or photographs. They were asked where in the museum they thought the character on the map was standing or if they could walk to the right position. After they found or mentioned the correct spot, the other map was shown to them. The test person was then asked if the other map would make finding the location easier than the one they had in hands. The map-test was done with 10 persons; two staff members of TTH (46 and 49 years old), two volunteers of TTH (both 68 years old) and six children from 8 and 9 years old. Seven of the ten test persons choose the map with photographs on it, but they were all not strongly in favor of one of the maps. However, it can be concluded that the objects on the maps were recognized and persons can orientate themselves by mapping the objects on the map with the objects in their surroundings. More information on this test can be found in Appendix K.

Moor et al conducted a test on preferred icon sizes; they used different sizes and scaled photographs and drawings of food items mixed together. The younger people (25-30 years) did not have a preference for illustration or photographs, but the older people (75-85 years) preferred the photographs because they found them more realistic and clear [36]. In the map test three of the four adults (45+) choose the photograph representation.

Photographs will be used for the Multimedia Guide in the first place, partly because the test and the research from Moor et al point in that direction and partly because is easier to make photographs than it is to make illustrations, both now and in the future. Museum objects will come and go, and the representation of these objects will have to be updated on the Multimedia Guide map.

Different map types

Before drawing a map for TTH and the Tuindorp district (outdoors) the type of map had to be determined. Therefore a collage was created of different map types found on the Internet that are currently used by map-based mobile guides [16], like black and white sketches, 2D-maps similar to paper maps and animated 3D maps.

The maps that were found to be best were maps that: appear to be 3D, show two or more sides of the buildings (objects), use colors that are easy distinguishable, and do not show too much detail. The maps that use this technique all seemed to be of University campuses, places were people find there way mostly when walking or riding a bike. As stated by Bin and Xiaobai: in pedestrian navigation contexts, landmarks are more required than information such as distances and street names [22]. The University campus maps also use landmarks (big and important buildings) instead of distances and street names. Some of the maps use a bird eye perspective. This perspective can not be used here however, because to it is easiest to map the location of the Assistant to a map with a Cartesian

coordinate system, in which the corners of a building transform linearly. A map using a birds eye perspective could be used in theory, but is much harder to implement.

The map that will be used is a combination of a 2D and a 3D map. The map itself is 2D, like a paper map, but the objects on the map are placed in a 3D perspective view for maximum recognition.

Demonstration map

The maps used during the demonstration at the TTH is displayed in figure 9.22 below. All objects outlined with pink, and with a pink background color, contain information.

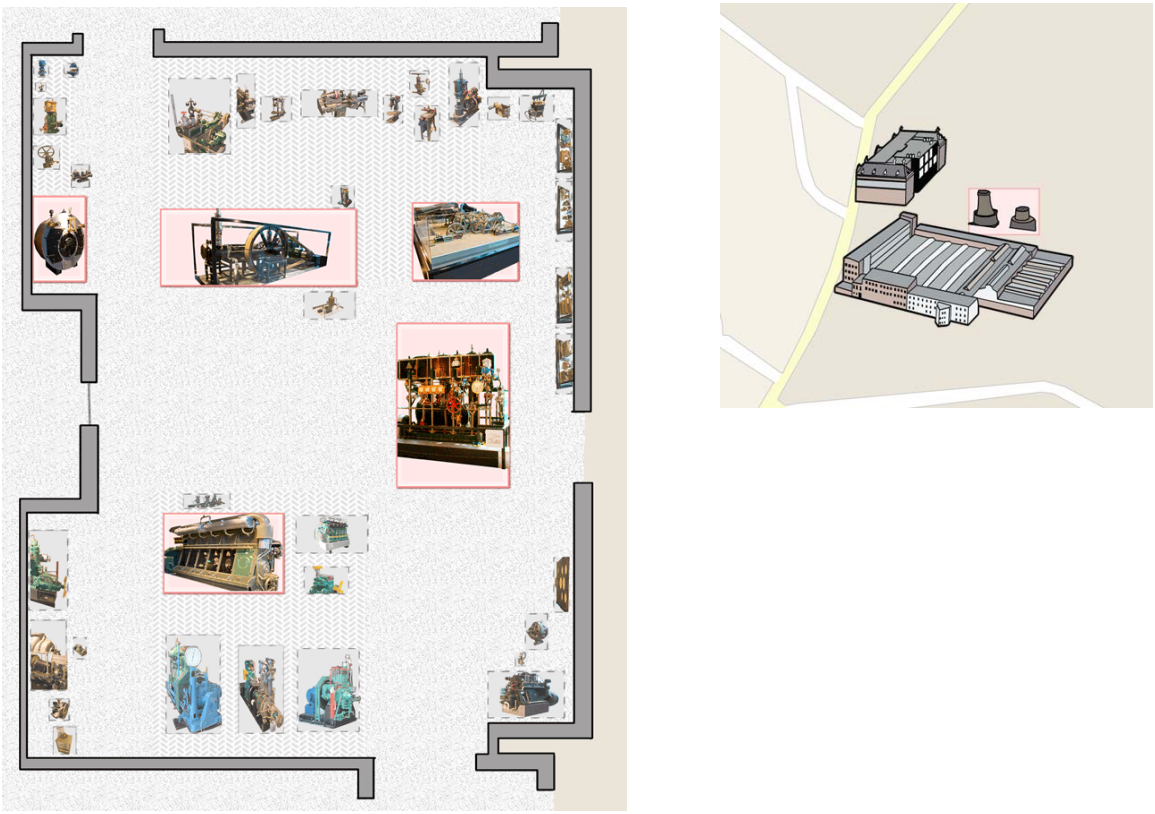


Figure 9.22: *The indoor and outdoor map, designed for TTH.*

When photographing the museum objects so that two or more sides are visible and the object can easily be recognized, the shape of the object will probably look different than the shape of the actual ground space it consumes. The ground space, however, is the area the user actually perceives and therefore has to be visible on the map. The solution used is to display the ground space the objects consume on the map and to place a picture of the object in this area.

The outdoor map contains only three objects at this moment, the TTH itself, the Stork Cooling towers and the building next to the TTH. The underlying map is adopted from Microsoft Live Maps, and the buildings are drawn with the help of aerial photographs (bird eyes view). Making good photographs of buildings that will easily be recognized by users is difficult; therefore illustrations are used for the

outdoor map. Eventually all major buildings of the Tuindorp and Hart van Zuid district should be drawn and placed on the map.

The floor of the indoor map is filled with a texture to counter a problem that can arise when the user is standing in an area and no objects are in his vicinity. The user would then only see white on his screen (the floor) and may not notice any activity when he moves around slightly. In this case the user might think that the map has stopped working. By giving the floor a texture the user gets immediately feedback from the screen when moving around because the texture will also be moving.

Objects inside exhibition cases may be too small to be shown properly on the map. The objects will be too small to click and too little to recognize. A solution is to show the exhibition case as one object containing more objects, to zoom in on the exhibition case, or to enter in the object's number with the numberpad.

Interaction with the map

The map can be zoomed in and out and can be dragged so that the user can orientate himself. By dragging or zooming out, a larger area of the museum becomes visible and the exit or already visited rooms can be found. As stated in section 9.3.1 all buttons are activated on mouse down (also called 'direct on'). It that case the map can only be dragged if the user does not place his finger on an object, because that would open the object. Dragging can be made easier by changing the interaction of the map to only opening objects when the land and release take place on the same object, but that would be inconsistent with the rest of the interface.

The object on the map differ in size, and because of that not all object will have the minimum button size. But because the map can be zoomed in and out, the minimum button size of 17x17 mm can also be reached for small objects.

9.5.4 Help function

It is expected that users do not need or will not ask for help on specific buttons but would like an introduction of the Multimedia Guide. An important aspect to assure that older adults are willing to use new technology is giving an adequate instruction about how to use the system (as mentioned in section 9.1). An introduction movie can give that adequate instruction, making the user feel more self-confident (requirement 4) to work with the interface.

The Multimedia Guide designed by Antenna Audio for the Dutch Van Gogh Museum makes use of such an introduction/help intro movie. It starts with an introductionary talk by the (former) director. Afterwards the Multimedia Guide is explained using a movie and a narrator. A disadvantage of this particular introduction movie is that it uses hard to see small white arrows to point at interface elements causing the user to easily miss what the narrator is talking about.

It is expected that an introduction movie, when implemented properly, will give users a adequate instruction. For PIA two introduction movies have been made: one for the interface with a numberpad, and one for the interface using a map. These introduction movies have been used during the user test at the TTH. Figure 9.23 shows some screenshots of these movies. User reactions on these movies can be found in Chapter 10: Evaluation.

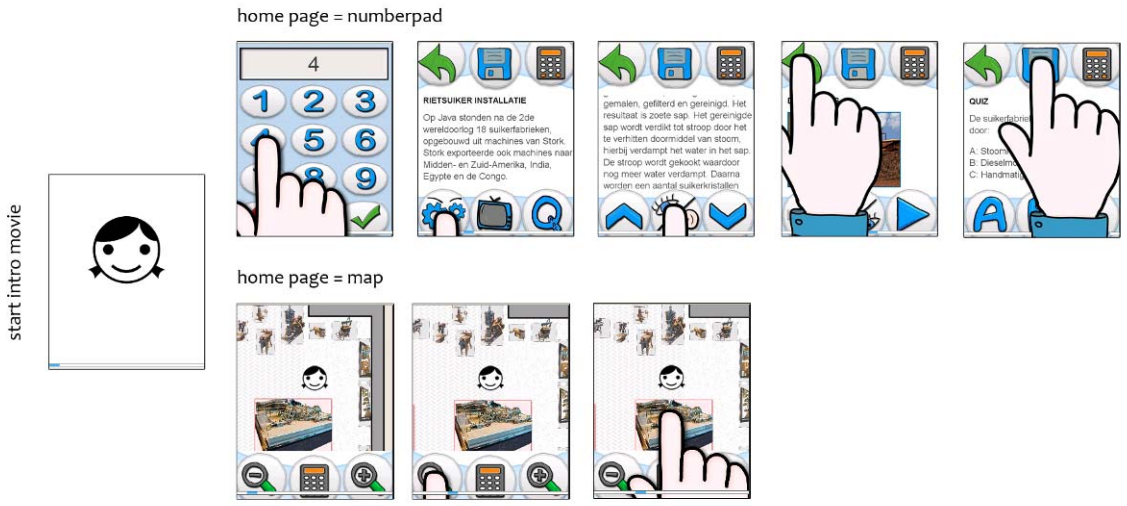


Figure 9.23: *Screenshots of the intro movies.*

9.5.5 Scrolling text

An advantage of the ability to scroll text is that it makes the length of texts independent of screen-size. This means content creators are not bound to a maximum amount of lines in one item of text. But some people, especially older adults, can have difficulties scrolling [31]. Paging may be a better solution; at least scrolling fluently is preferred over jumping per line [40].

During the demo at the TTH some remarks were made about the scroll functionality. One touch on the scroll down button meant the undermost text line would scroll up to the uppermost text line. One user mentioned that she was trying to continue reading while the text was scrolling, which she found a burdensome thing to do. Another user remarked that the scrolling was going too fast. He preferred to have the text shift in one step, because then he would not have to search for the current line. When a PDA with a double resolution screen (640x480 pixels) was shown to these users they both agreed that this looked more user-friendly. This PDA was scrolling with half a page when one of the scroll buttons was clicked and the text moved very slowly because of the PDA's processing speed. Both users could read the text while it was scrolling. This was in fact not the intention of the scroll functionality. It would be a difficult thing to achieve, because each user has a different reading speed. The underlying problem of these users is to pick up the current line after they have scrolled the page.

As a solution the number of scroll steps was reduced and a visual aid (displayed in figure 9.24) was added to help users recognize the current line. This aid helps the user to follow the current line with their eyes and to pick the up the line's location easily. The aid in the margin guides the eyes to the current line by using a gradient with two dark spots.

Figure 9.24: *The four pictures visualize one action as a result of a click on the down scroll button.*

9.6 Feedback

Giving the user feedback on his actions, so that the user knows that the system received his command, is very important. Feedback includes information about operation states, button states and notifications. This feedback has to be given in a way that does not interrupt the user's natural work flow.

Feedback in general can be given in a visual, auditory or tactile manner [30]. The used PDAs are not able to give tactile feedback like vibration or movement of the screen. Auditory feedback is not a good option because it can interrupt the user when he is listening to audio. Visual feedback is therefore the only form that can be used on PIA. It can be noticed quickly because people look at the screen when touching a button.

The different states to which the interface needs to give feedback are:

Active state – on successful button clicks
Visited state – on visited pages
Disabled state – on buttons that are not clickable at the moment
Bookmark state – on bookmarked objects
Loading state – when the application is loading a page
New message state – when the user receives a message.
Battery low state – when the battery is running low

These states will be treated one by one in the following sections.

9.6.1 Active state

The active state is shown right after a successful click, to let the user know that his command has been received. During the design process the active state feedback was redesigned multiple times.

During **paper prototype** testing, the direct feedback was given by the tester. The feedback consisted of a new screen (new paper) on the table.

During **digitized paper prototyping** direct feedback was given by the browser using an outline (a black border) around the clicked area. Because the drawn buttons already had a black border the outline was not always clearly visible. Occasionally when a button was clicked but the click was not successful, people waited a while before clicking again, or clicked something else because they thought the area was not clickable after all.

In the **coded prototypes** the direct feedback is given by the buttons, by showing their active state. In the active state the buttons gain a yellow glowing border as shown in figure 9.25. The museum objects on the map show an outline when the click was successful. The yellow glowing button work well as active state feedback. However, the difference in contrast between white and yellow is not very high, so outside on a sunny day the outline will be less visible.

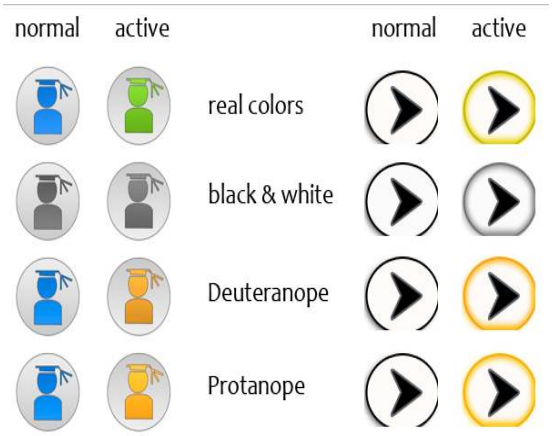


Figure 9.25: *The different ways of giving active feedback from the buttons of the coded prototypes.*

The first version of the coded prototype CP ui3b gave direct feedback by reversing the button's background gradient. However, the change of the gradient was hard to notice. In the second version of the CP ui3b interface the direct feedback was given by changing the color of the icons from blue to green. The users noticed the feedback on their successful actions during the user test with this interface. The contrast between the chosen blue and green is very small, but the colors are well distinguishable by color-blinds as can be seen in figure 9.25.

The demo version of PIA used a form of motion change for the icons, in order to give direct feedback. The icons become bigger in active state; color changes were not used. Again, the feedback on successful actions was noticed.

The best way of showing the active state feedback can not be concluded based on the conducted user tests. The sensitivity of the screen, the different ways people touch a button (long, short, hard or soft) and the processing speed of the PDA are of great influence on the ability to test which form of active state feedback works best.

When touching an area on the screen with a finger, the finger might occlude the information immediately below it. The user may therefore miss the active state of the button he presses. So what PIA needs is an active state feedback that is noticeable when the finger is still on the screen. A change in size is better than a change in color or shape, because "small periodic motions are generally better signals than color or shape cues across the entire visual field." according to Batram et al [41].

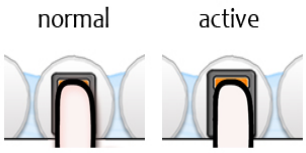


Figure 9.26: *The active state feedback used on PIA, the demonstration interface.*

Shen et al had the same problem when designing a direct-touch tabletop. Traditional pointing device systems generally offer in-place visual active-state feedback like highlighting or drop shadows. On a direct-touch interface like the Microsoft table and a PDA, this feedback can be occluded by the user's hand, causing the feedback to be missed. Shen et al described an on-screen aid called the DiamondSpin

as solution to this problem. The DiamondSpin enlarges and grows transparent temporally, when it is active, to give visual feedback [37]. If the buttons on PIA enlarge in active state (figure 9.26), this may be better visible than a change in color or shape, because the icons grow bigger and thereby may become visible around the finger.

9.6.2 Visited state

Showing the user which objects and information sources he already has seen is done by the visited state feedback. During user tests with PIA, people often asked: "Have I seen everything?" or "Didn't I already visit that object?" Of course it would be different if the people tested stood in the actual museum and if the map was really giving their accurate position. But it made clear that people want to have feedback about the things they had already opened. The way PIA is programmed at the moment, it is not possible to show visited states. But when it will, the visited state can be shown by changing the icon's color, like hyperlinks commonly do in a web browser.

The museum objects on the map also have to show their visited state. This can be done using a colored overlay or border.

9.6.3 Disabled state

A disabled state shows the user that a button is not clickable at that moment. When a movie doesn't include subtitles, the subtitles button will be disabled. And when the map is zoomed out maximally, the zoom out button will be disabled. Removing the button is not an acceptable option, because that would be inconsistent and therefore confusing.

The **paper prototype**s did not show disabled states, every form of feedback was given by the tester. In digitized paper prototype DP ui2 the disabled state was only given for the zoom buttons. For the users testing the interface it was hard to figure out if buttons were disabled or just not responding. Most users did not detect the zoom buttons becoming disabled when the map was totally zoomed in or out, probably because of the lack of contrast.

The **digitized paper prototype** DP ui1, shown in figure 9.27, gave more feedback on active and disabled states. The disabled state of zoom buttons was still not noticed by the users, but they did notice disabled information sources when they opened an object.

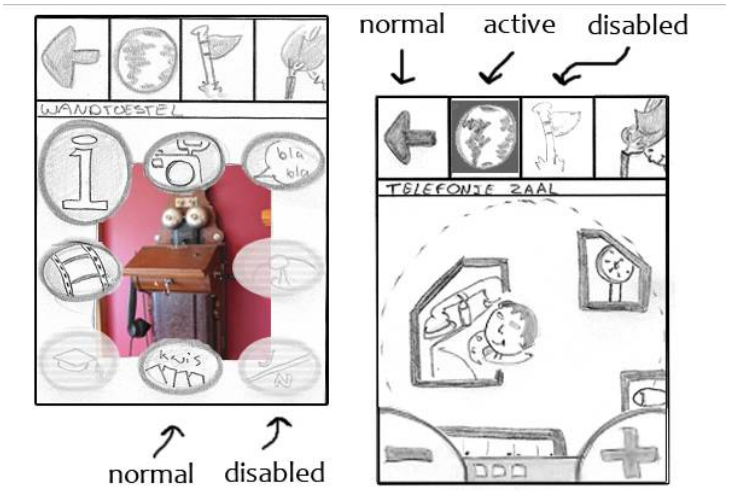


Figure 9.27: The active and disabled state feedback of DP ui1.

In the other versions of the **coded prototypes**, three different forms of disabled state feedback were tested, numbers 4 to 6 in figure 9.28. The difference between clickable and non-clickable buttons was more clear to users. People still tried the buttons; mostly just to be sure they are really disabled. While zooming in an out people often tried to zoom further than possible. It might be a solution to lighten the disabled states of the buttons more, but it should be tested if the buttons are still visible in sunlight then.

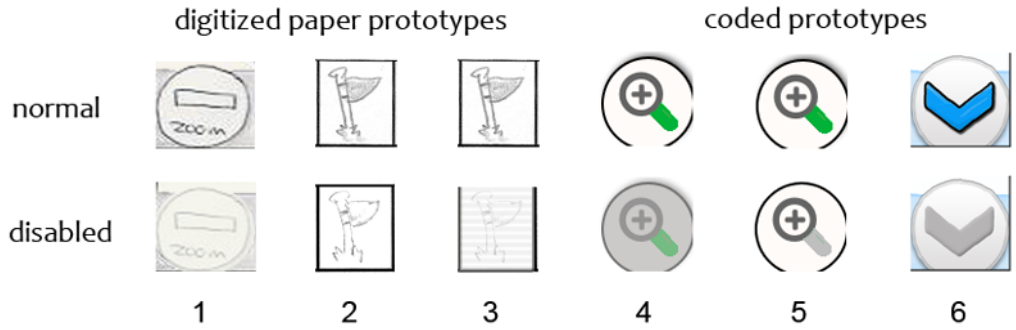


Figure 9.28: *The normal and disabled states of different digitized and coded prototypes.*

The objects on the map must also tell the user if they are clickable or not. When no information about a specific object is available, the object is visible for orientation, but is not clickable. The non-clickable objects may be grayed-out.

9.6.4 Bookmark state

The bookmark button has a normal state and a bookmarked state. Both states have their own active state. During paper prototyping and digitized prototyping the bookmark state of the bookmark button was not directly tested, but often led to discussions. One of the digitized prototypes used the normal state of the bookmark button on some of his pages and the bookmarked state on the other pages, the user could not use the button but was exposed to both states of the button (number 1 of figure 9.29).

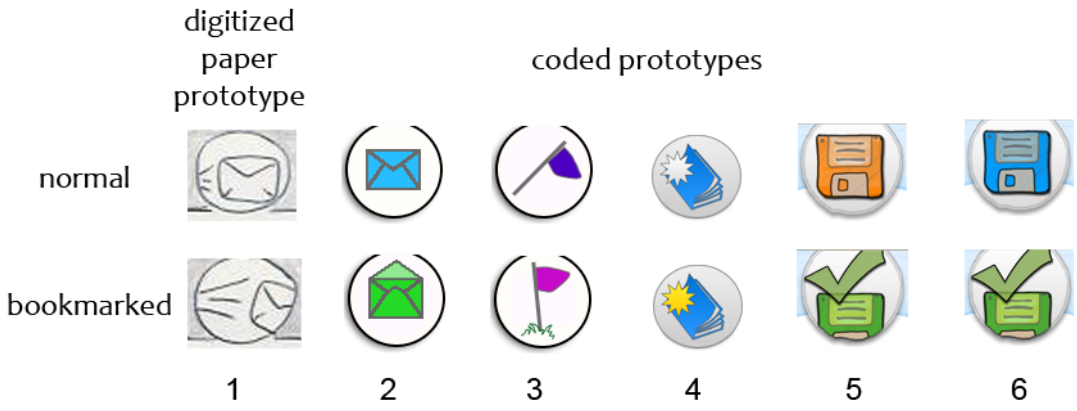


Figure 9.29: *Different bookmark icons and bookmark states used in the digitized and coded prototypes.*

In the coded prototypes four different icons were used, which can be seen in figure 9.29, and the user could really use the bookmark button. Only a few users guessed the purpose of the bookmark button. Most of the users understood what it did after explanation. Besides explaining the bookmark function in the introduction movie, it would also be helpful to give a textual message as feedback when the user uses the bookmark button for the first time.

The difference between the normal state and the bookmarked state is very important, because the user must have the feeling that he has actually triggered an action by clicking on the bookmark button, instead of just changing the icon. For example, the flag illustrates that someone plants a flag near the object in order to be able to find it back. The normal state of the button illustrates the flag unplanted. Most users understood the metaphor after explanation, but even then didn't see a real difference between having the object bookmarked or not.

The map could also show if an object is bookmarked or not. If an object is bookmarked it is also visited. This particular problem needs more research.

9.6.5 Loading state

When the browser is busy loading a new page it has to show the user that the interface is in loading state. Showing the page being build up is very chaotic. Instead of showing the user how the page is build up, we prefer to show the new page at once. In the mean time the browser is in the loading state. The interface needs to show the user that it is loading to let the user knows something is happening [30]. This dynamic feedback is given by a loading animation, which is visualized in figure 9.30 below.

Figure 9.30: *A visualization of the loading animation used in PIA.*

9.6.6 New message state

One of the extra functions of the Multimedia Guide is receiving museum notifications. The museum might send a message to the user, like: The next show starts in 10 minutes. These messages, send by the museum, need to attract the user's attention without interrupting the user's work flow.

Blinking elements in user interfaces attract visual attention, but when too many items are flashing it becomes annoying [41]. In his book, Fisk suggests to use blinking for a visual message that is intended to draw attention rather than letting in appear instantaneous [31]. In the digitized paper prototypes the reception of a museum notification was simulated by letting the assistant show an envelope. Most users did not notice the envelope when it suddenly appeared.

For the new message state a blinking motion type is created, visualized in figure 9.31. However, this part of the interface has not been tested because it cannot be easily incorporated in the coded prototype.

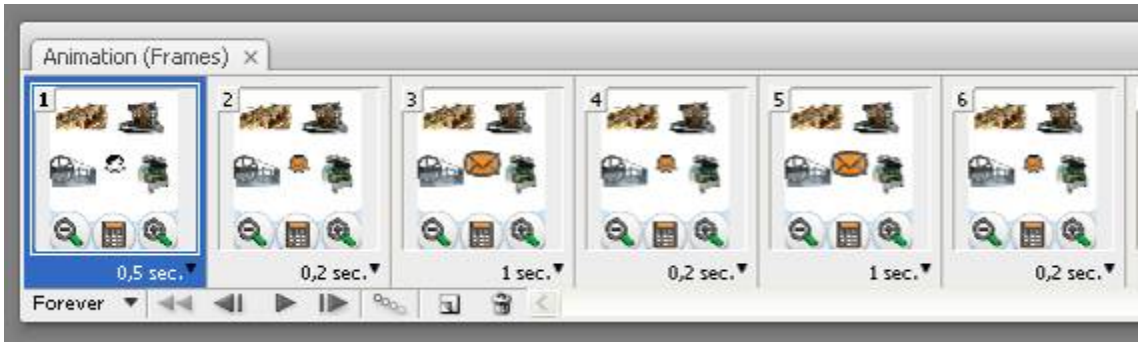


Figure 9.31: *The blinking motion that is created for the new message state.*

9.6.7 Low battery state

The user has to be informed if the battery is running low. Knowing that the battery is running low, the user can decide to pick up a new PDA or turn it off temporally when it is not is use. Either way, he won't be surprised when the device stops operating. In the same way as the 'new message' notification, the assistant will give this notification through a blinking 'low battery' icon. The icon will start blinking slowly and blinks faster if the battery is almost empty. The 'low battery' icon can be clicked, like the 'new message' icon; PIA will then give some information about what to do.

9.7 Use of color

Color can be very helpful to provide structure to different parts of the interface; it can visually group or improve the discriminability of icons [34]. But, color should not be the only characteristic that differs between icons; it should be used as an aid [30].

When the colors are being used as coding no more than seven colors should be used if the colors are close together, and no more than four colors if they are scattered [33].Cushman and Rosenberg suggest using the colors, red, yellow-green, green or white, cyan and blue when users can have a form of colorblindness [34]; eight percent of the male and one percent of the female population suffers from a form of color blindness [30]. All three forms of color blindness can be simulated by an Adobe Photoshop plug-in called Vischeck [42]. By using that tool, the designer can keep an eye on the effect of the chosen colors to the color-blind.

The colors red and green have strong associations in user interfaces. These associations listed here are adapted from Cushman and Rosenberg:

Associations with red:	Alarm, critical, disabled, emergency, failure, stop.
Associations with green:	Active, enable, normal, on, on-line, run

Because nothing on PIA is critical, the color red will not be used. Bright colors (yellow, orange, red) draw the eyes [30], so yellow or orange colors might be used for warnings or notifications instead.

9.7.1 Color and Contrast outdoor

Environmental lighting and reflections of illuminated objects reduce the amount of contrast between elements on the screen. To compensate for this, the difference in luminance between fore- and background (the contrast) should be as high as possible. The luminance of light colors on the PDA display is far less influenced by environmental light than dark colors [40]. That is because a dark color, like black, is produced by blocking the backlight of the TFT screen. Black is the absence of light but because TFT screens are not able to totally block the backlight, the perceived color is dark grey instead of black. Current PDA screens use red, green and blue subpixels, the primary colors of light, to produce all colors. White light is obtained when the three primary colors are perfectly mixed. When colors with 100% brightness are produced by a PDA screen, a pixel lets the backlight go through one or more of its subpixels completely. The reflection of ambient light perceived by the eye is much less when a bright color is emitted by the screen. Of course there is still reflection of ambient light on the screen but the amount of light from the screen itself is stronger than the amount of reflected ambient light.

New screen technologies are in development offering better contrast ratios than current PDA screens. Presumably the future will bring screens on which readability in sunlight is as good as text on paper. Until then use of the right colors in the interface might improve the readability of the screen in daylight and/or direct sunlight.

The luminance of the screen is highest when the PDA screen shows a completely white screen, because then all the light from the backlight is let through. To find an appropriate substitute for black, a color has to be found with a 100% brightness (to minimize the hindrance of reflections) and the best contrast with white. In figure 9.32, seven different 100% bright colors from the color spectrum are shown with the corresponding grayscale. The darkest 100% bright color is blue (0,0,255) and is therefore the best substitute for black. With the same level of brightness blue appears darker than red and green, because the eye is less sensitive to blue [43]. The eye's retina and lens turn more yellow with the years, resulting in a disturbance of blue light [44]. That means that elder users perceive blue color more like black.

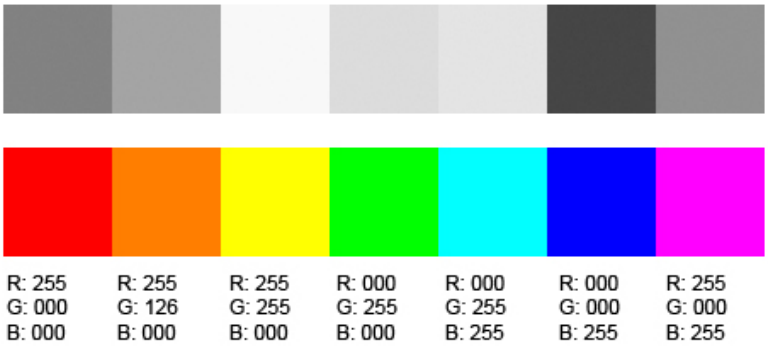


Figure 9.32: *Seven 100% bright colors with their corresponding grayscale.*

The brightness difference between white and black is 597 and between white and blue 529, according to the color contrast verification tool of HP [45]. The difference between white and blue is not as high as that of black and white. Because the eye is most sensitive for yellow (to be exact yellow-green with a wavelength of 550nm [46]), it would be interesting to test a combination of yellow and blue on a PDA screen outdoors. The complementary color of blue (0,0,255) is yellow (255,255,0). In this case, the brightness difference is 461. Although the luminance of yellow is less than white light, for yellow light only 2 of the 3 subpixels let light trough. The subpixel that is blocked, however, is the one at which the eye is least sensitive: blue.

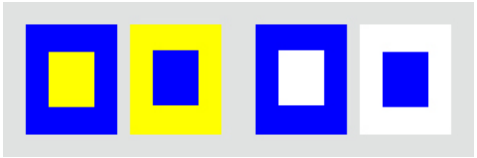


Figure 9.33: *The combination of blue and yellow and blue and white.*

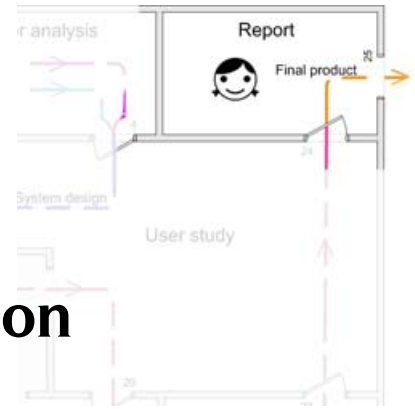
So when PIA is used outdoors, blue text on a yellow or white background should be used (figure 9.33 shows these combinations). When using positioning technologies it can determine if PIA is indoors or outdoors. Based on that knowledge, the screen colors can be adapted automatically.

Part 3: Evaluation

Part 3 is the evaluation phase. Chapter 10 describes the Evaluation of the designed Virtual Museum by means of a demonstration that was given at TTH, and by comparing the designed Virtual Museum and specifically the Multimedia Guide with all the requirements and guidelines that were formulated throughout this report. Some other applications for which the concept of the Virtual Museum might be used are also explained here. The Conclusion with recommendations is given in Chapter 11.

Chapter 10

Evaluation



In this chapter, the Virtual Museum and the Multimedia Guide in particular are evaluated to determine if they enhance the museum visit and improve visitor involvement and if they comply to the requirements and guidelines formulated throughout this report. The Multimedia Guide is one of the six pillars of the Virtual Museum, its final design is tested during a demonstration at TTH, described in section 10.1. In section 10.2 the Multimedia Guide, the used content and a part of the Virtual Museum is evaluated by means of the requirements of Chapter 4. The guidelines used in this thesis (which can be found in Appendix H) are also used to evaluate the Multimedia Guide and its content in section 10.3. The Virtual Museum as a whole, could unfortunately not be tested, because not all necessary pillars are available yet.

The basis of the Virtual Museum can also be used in other scenarios besides museums. Some ideas are presented in section 10.4 to evaluate the applicability of the Virtual Museum for other purposes/scenarios.

10.1 Demonstration

A demonstration of the Multimedia Guide has been held at TTH. During the demonstration, the Multimedia Guide was tested by employees and volunteers of TTH and SIS.

The demonstration was given to present the Multimedia Guide to all stakeholders. To be able to determine if the project goals are reached. the final design was tested in the environment it was designed for.

Content related issues could not be tested because the quality of the content was not sufficient enough. Recommendation for the content are given in section 7.4.

10.1.1 Demonstration goals

With the demonstration we want to specifically reveal if the following requirements and guidelines are met: Users should find the guide easy to use and comfortable to carry around (requirement 14); The museum visit should remain a social matter and people should still able to use both of their hands to

interact with the museum's objects (requirement 8 and 21); The Multimedia Guide should entertain the visitors and encourage talking and sharing among a group of visitors (guideline from Appendix H); The museum's staff members and volunteers should be enthusiastic about the system. (guideline from Appendix H) These are requirements and guidelines that could not be tested before, outside the museum. An important aspect of the Information Assistant, if people can navigate and orientate with a the designed map based interface has also not been fully tested before.

A questionnaire drawn up for test persons to fill in after the demonstration. This questionnaire can be found in Appendix K. Using the answers to these questions, it is possible to determine if the above mentioned requirements and guidelines are met.

10.1.2 Test set-up

A flash introduction movie has been developed to explain the user the structure of the interface. It is expected that people interact more confident with the interface if they know what to expect. In the introduction movie a narrator tells what happens on the screen and what can be done with the Assistant. A picture of a hand is used to perform all click actions. Before the guides are given to the test persons with the introduction movie running, the user is asked if he preferred to listen or to read, and if he preferred normal size characters or large size characters. Because of the small amount of content available no filtering of the content was included.

As a backup option to the map start page a numberpad start page and accompanying intro movie have been developed in case the indoor positioning system would not work properly. Unfortunately, the numberpad had to be used during the demonstration. Therefore, the map interaction could not be tested during the official demonstration.

The interface used during the demonstration is the one that was found to work best during the user tests, with 3 information sources in the object menu as seen in figure 10.1.

Figure 10.1: *The interface as used during the demonstration.*

Four different PDAs were used for the demonstration, in order to be able to test the differences between them. Between the PDAs there were, differences in brand (HP, E-ten, Mio, Asus), screen resolution, screen size, processing speed and versions of the mobile operating system. During the test

two PDAs were equipped with earpieces and a volume control, one PDA was linked to a Bluetooth earpiece and one PDA used the speaker for the audio output. Three of the PDAs were wrapped to cover the buttons and make them more shock resistant, and were provided with a elastic cord to wear it around the neck.

10.1.3 The test

Before starting the test, the Multimedia Guides were laid down on the presentation display of the Triple Expansion, the museum's showpiece and centered in the middle of the room, where the demonstration took place. Staff members and volunteers of TTH and SIS were asked if they preferred large text or normal text, and if they preferred to listen to the information or preferred to read the information. The matching page with the intro movie was then opened on the Multimedia Guide. After this, the device was given to the user who would hang it around the neck, and if available put on the earpieces. While the user did that, the movie was already playing so it had to be restarted.

Because there were more people then Multimedia Guides, some people had to wait until they could get one, or watch someone else's Guide. Figure 10.2 shows two photographs made during the demonstration.

Figure 10.2: *Photographs made during the demonstration.*

Because the used content did not do much to divide the user's attention, and because some problems were encountered during the test, not al demonstration questions can be answered. The questions that can be answered are treated in the next section. For a following demonstration the questions as stated in Appendix K can be reused.

10.1.4 Results

The Multimedia Guide has been tested by 12 people in the museum, of which eight during the official demonstration. Four others tested the Multimedia Guide in the museum after this demonstration, with some improvements.

All 12 persons who tested the Multimedia Guide in the museum were enthusiastic about it. Figure 10.3 shows three users, interacting with the guide. Positive comments were made on the Assistant's appearance and the voice used for the object information. Some had seen sketches of the Guide's interface in an early stage and were impressed by the professional look it had now. But fortunately the test persons were also critical towards different elements of the Guide, making it possible to reveal the aspects that needed improvements. Some positive comments:

> *"I found the movie about the sugarcane factory very interesting, but also all other information I listen to. I was less interested in reading the texts. Some of the information the Guide gave me was too simple, but it was still useful information. I really learned something new about the steam boiler and looked at it in another way. Really nice! "*
>
> *"The interface looks really good and very clear, did you also took care of the media and the map?"*

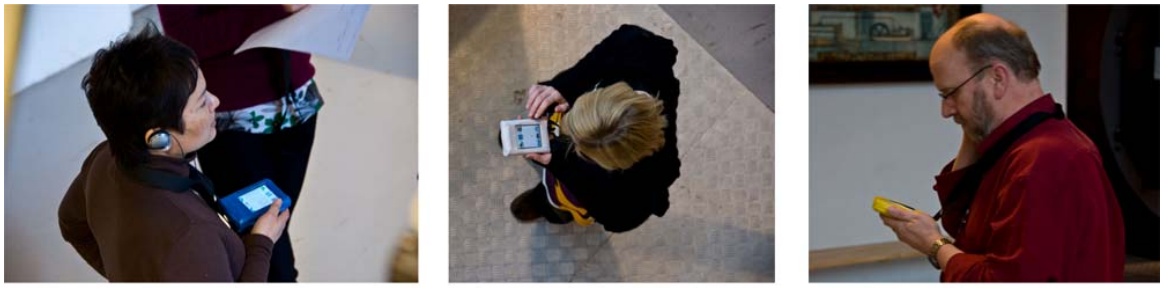


Figure 10.3: *Three test persons during the demonstration interacting with PIA.*

Important observations, comments and answers on questions are ordered into the corresponding subjects and mentioned below.

Audio

Unfortunately the museum was very noisy during the Demonstration. The audio files were thought to be loud enough when testing them in an office surrounding but proved to be too soft in the museum. When machines in the museum were operating, the audio was found too soft even if two earpieces were used. Because the audio could not be heard properly, all test persons missed the audio of the intro movie and therefore its purpose.

Intro movie

The movie started right away, causing test persons to miss the start.

Scrolling texts

Some comments were made on the way the text scrolled. One test person mentioned that the text was hard to read when scrolling, she had the feeling that she had to read the scrolling text. Another test person, that also found the scrolling too fast, suggested to move the text in one step instead of scrolling it to help with the fact that people must find the line they were at after scrolling. They both

found the scrolling on the E-ten PDA much more comfortable; this one scrolls two times slower than the other ones. With the E-ten they are both able to read the text while it is scrolling.

Earpieces

The Bluetooth earpieces were having problems connecting and made a cracking sound. The other earpieces stayed attached to the test persons ears, but some of them had difficulties placing the earpieces because they had never seen the specific type of earpieces before.

Content

According to the museum's staff members of education the quizzes are extremely nice for kids, every object should have a quiz.

The texts used by the Assistant, however, are probably not very suitable for 10 to 12 year old children, because they do not know the meaning of some of the words used. The texts should also contain more links, like to the fact that a dynamo is also used on a bike and steam also comes out of a whistling kettle.

Attention division

One test persons comments that she is mainly focused on the screen. She think the content should pinpoint here to the unique aspects of the objects.

Icons

According to the museum's staff members of education the icons are probably very useful for children and very clear to them.

Numberpad

Test persons were observed to enter a number on the numberpad and then wait for a while. After noticing nothing happens, they press the OK button.

Practical problems

Adjusting the Assistant to the personal preferences of the test persons is time consuming, the test persons have to wait for it. It would be better if the test persons can make the adjustment themselves during the demonstration.

Based on these results the following improvements were made: the flash introduction movie is adjusted in such a way that it needs less processing power from the PDAs; users can choose their own personal preferences and start the introduction movie when they are ready for it; the volume of the audio files is tuned up; and a visual aid is added to the scrolling text pages, making it easier to recognize the current reading line and continue reading.

After these improvements were made, four more people tested the Guide in the museum. In the mean time the map functionality with a working indoor positioning system had also become available.

No serious problems occurred; even the transition from inside to outside the museum was experienced as good.

Outside the museum, more people have tested this improved demonstration interface by using the numberpad as homepage instead of the map. Revealed problems include that the intro movie can not be skipped when it is running; some people try to manipulate the interface while it is still in the introduction movie. The selection of the personal preferences gives some problems because, the text itself is sometimes selected when a user presses the link, instead of opening the link. This can be solved by ysing images instead of links, like all other buttons in the interface.

10.1.5 Conclusion

The demonstration at the TTH and the user tests conducted afterwards show that people can handle the Multimedia Guide and that they like working with it. Some people had some difficulties in understanding how to wear the earpieces, but could use them after demonstrated. Most of the test persons were very much aware of the fact that they were testing the devices. This test awareness leads to the fact that the test persons were easily giving comments on aspects of the Multimedia Guide. Some of the persons were really using the Assistant to gather new information about the objects, they got new insights on objects and especially liked the videos and animations. Some other test persons, were discussing and talking about the Multimedia Guide but not about the content. So the Guide supported talking and sharing within the group, but the talking was more about the Guide itself than about the information it presents.

Because the test persons were mainly museum staff members and volunteers, and because all test persons were enthusiastic about the system it can be concluded that museum's staff members and volunteers are enthusiastic about the system.

To determine if a museum visit is still a social experience, if the user attention is evenly divided between the Guide, the museum objects and the surrounding, and if the Multimedia Guide does not stand in the way of a hands-on experience, a group of schoolchildren will probably be the best test group. But before a demonstration with schoolchildren can take place, the content has to be made better suitable for this user group. After the demonstration, the TTH started reviewing the content and will adapt it to the children's needs. When this is done the audio needs to be recorded again before a second demonstration can take place.

10.2 Requirements

In the research phase of this project requirements and boundary conditions were defined by a market research, investigating similar projects and unveiling user needs. The designed products can now be evaluated by means of those boundary conditions and requirements listed in Chapter 4.

B**oundary conditions** result from the original project assignment; the designed Virtual Museum complies with the 8 boundary conditions presented in Chapter 4: The Information Assistant is web-based and can be filled with all kinds of media, it is based on a PDA with a cord and earpieces. The

information that the Assistant presents is linked to the location of the user by using indoor positioning technologies and a map based interface or by using object numbers that can be entered on the Multimedia Guide. Before a museum visitor starts using the Guide he can give his personal preference, on the guide itself, on a terminal or at home through the internet. The Information presented by the Assistant is filtered based on these personal preferences. The Multimedia Guide is controllable by finger touch, by clicking on touchscreen buttons. The system is information pull-based, so that the user is in control of the information he consumes, and divided in small chunks from which the user can choose. When consuming the information the user can switch from communication channel (visual, auditory) so that his senses will not be restricted. The visitors can bookmark object by means of clicking on an object's bookmark button. Bookmarked objects can be reviewed from home through the internet.

Requirements 18, 25 until 29 and 31 from chapter 4 are aimed at the Back-end, the Front desk and the Website. These pillars are not developed and not tested and will therefore not be evaluated.

10.2.1 Multimedia Guide

Requirements 2 until 5, 8, 9, 12 until 17, and 19 until 24 are specifically aimed at the Multimedia Guide. Through testing it has been revealed that the Multimedia Guide meets most of the requirements. Some other requirements will need to be tested more.

Requirements that need more testing are: More testing and development is needed to make sure that a Multimedia Guide can replace the common audioguides and that the unwillingness to use it is not higher than that of an audioguide (2). A more natural test setting is needed to reveal if people are not bothered by other users working with the system (3), and if the museum visit remains a social experience (8). For this last requirement high quality content is also a necessity. To make sure users find the guide comfortable to carry and use the device (14) and that it does not stand in the way of a hands-on experience (21) it would be best to test it with children. Before a test in the museum with children (age 10-12) can take place the content has to be rewritten for this user group and recorded. By choosing PDAs with screens that are better readable in sunlight and by adjusting the colors when walking outside the content on the screen will probably readable in the different lighting conditions in which it will be used (15). To be sure, the adjusted color scheme for outdoor has to be tested during a sun shining day.

The other requirements that are specifically aimed at the Multimedia Guide are met: To make sure that novice users can work with the product within 5 minutes (4) an introduction movie was made so that novice users have seen the interface before using it. During user tests almost all users worked confidently with the guide within a couple of minutes without having seen an introduction movie. Users who seemed not to be confident gave the guide back within those 5 minutes. That might have gone different when they had seen an introduction movie. During testing script code or error messages never appeared (5). The Information Assistant uses only touchscreen buttons, making it easy to show only buttons or elements that are in use (9). Because no hardware buttons are used the Assistant is also independent from a specific type or brand of PDA (12). The hardware buttons are covered by a casing so as not to confuse the user and to make the device more shock resistant (9, 17). The casing also prevents the PDA from being dismount by users and prevents users from pressing the

reset button (16). When the PDA's battery is running low the user receives a warning from the Assistant to allow the user to go to a place to renew the battery (13). The volume of the Information Assistant can be adjusted in the interface, but a solution with a volume control between the PDA and the earpieces has also been tested. Because the volume buttons in the interface did not work and people did not try to use them during the last user test (the demonstration) it can not be said if this volume control works in a real situation. The physical volume control, however, was found and used by test persons during the demonstration. This physical volume control can be reached in one action, while the volume control in the interface not (19). All persons that have tested the Multimedia Guide longer than two minutes found it easy to use (20). By keeping the interface as simple as possible the interface has been made intuitive to use, user tests pointed out that users are able to use the Assistants without getting instructions (22). The interface is consistent and users can click on anything in the screen and anything can be undone (24). The navigational elements of the interface and their place in the interface are very similar to the navigational elements of a web browser so that they are recognized by users (23). The method of navigation is also consistent on every level of the interface (24).

10.2.2 Content

The content is a separate pillar, on which the Multimedia Guide heavily relies. Unfortunately, the quality of the content that was used during this project was not high enough. Besides giving information about objects, the content must also divide the attention between the museum object and the Guide, and must assure that interaction takes place between the user and the museums objects and among users if the user is part of a group. The content that is currently used by the Multimedia Guide does not support any attention division activities.

Requirements 6, 7 and 8 are specifically aimed at the content. Initially, the goal of de demonstration was to also test requirements and guidelines related to the content. Important content related requirements and guidelines in this respect are: The attention between device, exhibition and surroundings has to be well balanced (requirement 6); The system should be an aid for the visitor to find information he prefers (requirement 7); The museum visit has to remain a social experience, as it is in the current situation (requirement 8).

The content must assure that the user's attention is well balanced between the device, exhibition and surroundings. Ways to do this are discussed in section 7.4. A guideline that is already applied to the Information Assistant is dividing the information in small chunks (6). Furthermore, user tests pointed out that the quiz questions about the museum objects were very popular and also made people look around, to other people or to the museum object when they stood in the actual museum (6). During user tests the quiz questions also led to social interaction; test persons began to ask for opinions of other people in their vicinity, and people in their vicinity began to question the test person's choice (8). Whether people preferred the information they found with the Assistant (7) could not be tested because all test persons received the same content, it was not personalized. More and high quality content is needed to test this requirement.

10.2.3 Virtual Museum

Requirements 1, 10, 11, 18, 30 and 32 are about the Virtual Museum as a whole. The technology that is used, until now, works almost 24/7 and without maintenance (1). But, due to the low processing speed of the PDAs they easily freeze, when that happens the reset button has to be pressed; this can be seen as maintenance. Because software is heavily used inside the Virtual Museum, it is easy adaptable to a specific organization and audience (10). For example: by redesigning the icons used in the Multimedia Guide, a completely different look and feel can be accomplished, as can clearly be seen in figure 9.6 of section 9.2.5. Expressing one identity can be accomplished in the same way, by using one look and feel for all icons and elements of the different components of the Virtual Museum (11). All parts of the Virtual Museum should have a HEIM look and feel (30) but it is not easy to define this look and feel. The TTH's logo and brochures are mostly red, not a very useful color for an user interface. The last requirement, if the system attracts people to (re)visit the museum and to share experience with the museum and other visitors (32), can only be tested when the whole Virtual Museum is completed.

10.3 Guidelines

In Appendix H a list can be found with the guidelines defined throughout this report. This are: general interface guidelines aimed at handheld devices, elderly and icons; guidelines aimed at the multimedia guide and its content; and specific guidelines about use of color, navigating in the interface, a bookmark tool, and audio and text.. To what extent the designed Multimedia Guide fulfills these guidelines can now be evaluated. The guidelines for the guide's casing and the registration terminal are defined but not used during this project.

10.3.1 Multimedia Guide

The Multimedia Guide has been designed according to general guidelines. The interface is consistent so that the user knows what to expect after seeing the information for two objects, so the user can experience the tour in a coherent way.

The designed interface complies to all **handheld device guidelines**: the user gets feedback on all actions; by using a broad menu structure instead of deep the user is often giving the satisfaction of completion; the user is in charge of the system and initiates all actions; things that are clickable, look clickable; the used icons are clear to the users; when multiple platforms are developed the look and feel can easily be leveled, so they look they belong together; the interface and content can be adapted to personal preferences; the multimedia guide can be operated by one hand; the application adapts itself automatically to the user's current environment by showing him the object in his vicinity; the user can easily stop, start and resume audio and movies; the PDAs react on user commands within 1 second, which is found to be fast enough; the guide present high level information and lets the user decide to retrieve more detailed information; the concept of the multimedia guide allows the user to change settings; and, testing revealed that the multimedia guide is visually pleasing , entertains the user and is easy to use.

The interface complies to most of the **interface guidelines for the elderly**. It does not show visited states, making it harder to know which pages have already been visited.

As already stated in section 9.5.1 about the home button, the numberpad icon does not comply to all **effective symbols criteria,** all other used icons are effective.

The guidelines about what a **multimedia guide should** are already discussed in the conclusion of the demonstration, section 10.1.5. Unfortunately, the demonstration interface complies to one of the thing a **multimedia guide should not**. The application can freeze when more resource consumption is needed than there is available. All movies and animations should have a low demand on processing speed. The worst thing that happens is that the screen freezes, the user is never exposed to errors or script code. The application will not freeze if a user clicks on a button when the application is loading because it will not accept new commands when he is in a loading state.

In section 10.1.5 is was already concluded that the museum's staff members and volunteers are **enthusiastic**. From the two **navigation guidelines** only one is met. The interface has a unambiguous start page, but it does not show which pages have been visited. From the **guidelines for a bookmark tool** one still has to be fulfilled: The bookmark tool must be advertised online and onsite and specially aimed at the committed visitors. By making the guide's audio and text the **guidelines for text and audio** were carefully considered, making these guidelines also fulfilled.

The last **guideline for use of color**, using blue text on a white or yellow background for outdoor use, has not been implemented yet. That the designed interface uses colors that are also distinguishable by color-blinds is viewed in figure 10.4.

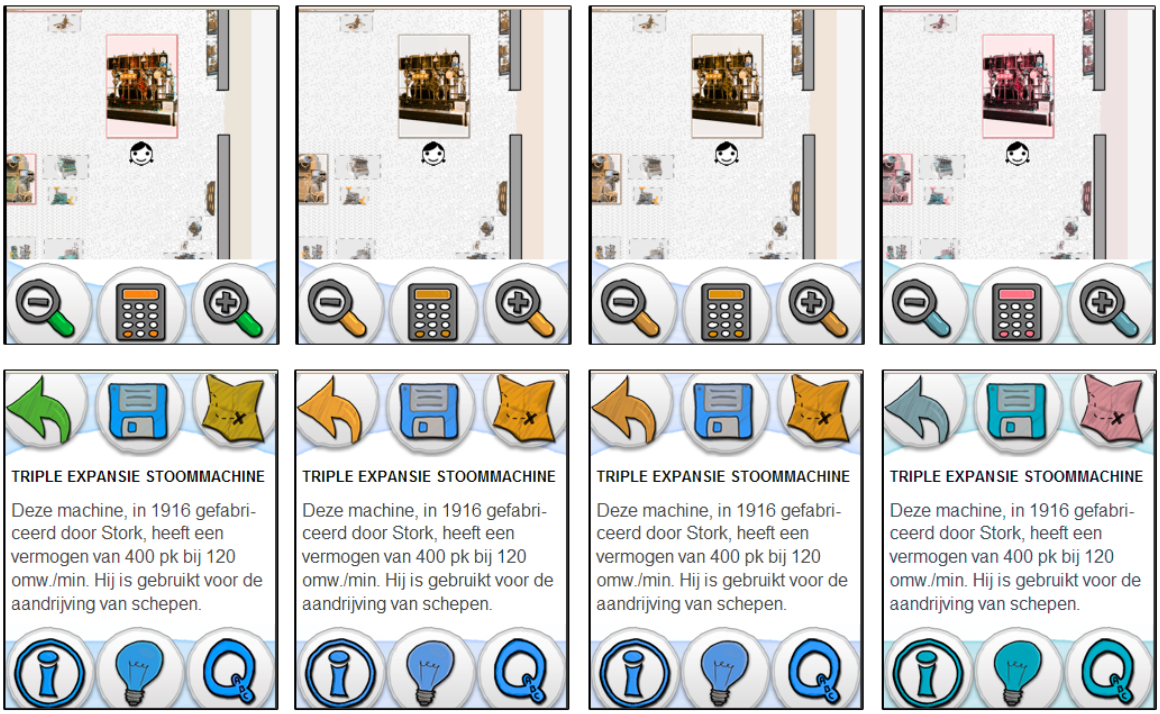


Figure 10.4: *The Vischeck color deficit simulator: normal, protanope, deuteranope and tritanope.*

10.3.2 Content

The four content guidelines from Appendix H that were written for the content are partly complied. The Multimedia Guide provides the user with more information than just the object's name, it really adds something to the museum experience. It gives the user the ability to choose between chunks of interesting information. The texts in the guide are satisfying when compared with the information in the museum in the current situation, but test persons that read the texts outside the museum did not seemed to be entertained by the texts provided by the Guide. The audio fragments from the same texts are appreciated more, partly because people like the voice that is used. The Multimedia Guide supports social interaction and discussion among visitors but it is not sure if this is because they are testing the Guide or that this will also be the case when the Guide is used by the future museum visitors.

10.4 Other applications

The concept of the Virtual museum and the Multimedia Guide can also be used in different applications. Here are some examples.

Rails

The concept of the Virtual Museum could be used by a train company. With Rails the user can use his own PDA (laptop) and browse to a specific website, provided by the train company, when travelling by train. The user receives a map from his surrounding and can receive information about places and objects he passes by (see figure 10.5). Companies near railways can advertise on this map.

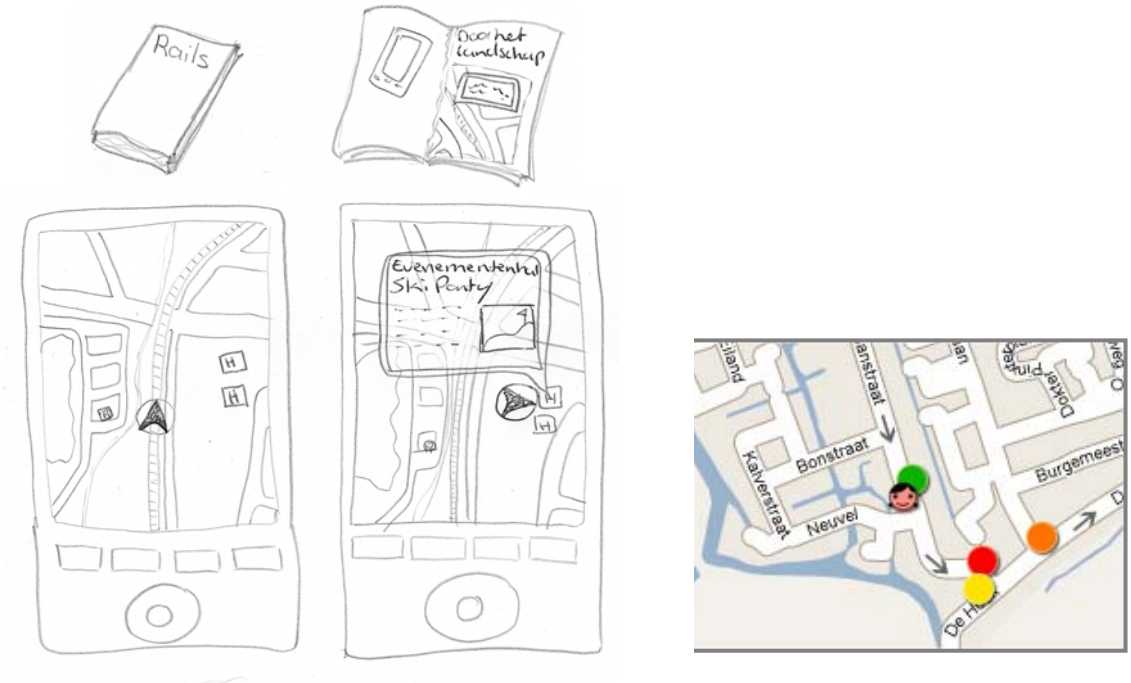


Figure 10.5: *A sketch of the Rails concept and a picture from the DorpsQuiz concept.*

DorpsQuiz

The DorpsQuiz builds on the success of the quizzes in PIA. It is an outdoor tour for groups of people. Each group of approximately 5 people gets one PDA, the PDA shows a map of the area, the location of the group and the places on the map where questions are located (see figure 10.5). There are questions on different subjects, like history, language, culture etc. The answers are filled in on the PDA and the scores of the group are stored on the PDA. For the DorpsQuiz a scenario has been written, this scenario can be found in Appendix J.

Staatsbosbeheer

Staatsbosbeheer is the Dutch organization that manages the forests. They already set out GPS tours, but with PIA they can make the forest come alive with information and quizzes about trees and landscape. The Virtual Museums CMS can be used to archive and disclose all information about, for example, the influences of climate change on the Dutch forests.

Chapter 11

Conclusion

This thesis has described the design of a Virtual Museum, based on the life cycle of a museum visit: before, during and after with an emphasis on the visit itself. Modern multimedia and internet technologies are combined in the Virtual Museum to enhance the museum visit and to increase visitor involvement. To enhance the museum visit, a product has been designed to assist, inform and entertain visitors during their visit. This product is named PIA, for Personal Information Assistant.

The Multimedia Guide PIA is one of six pillars of the Virtual Museum. The other five are: The Back-end, to maintain the content and analyze visitor's behavior; Location Based Services, to provide a position and accuracy of a visitor for use by the Information Assistant; A website, to expand, re-live and share the museum experience, involve visitors in the museum and stimulate visitors to revisit; Front desk, to store, recharge, update, clean, prevent theft, give instructions and hand the Information Assistant over to visitors; Content framework to provide the content makers with guidelines on how to create the content. Guidelines and requirements have been created for all of these pillars. The guidelines can be found in Appendix H, while the requirements can be found in Chapter 4. For the success of the Virtual Museum, two guidelines are considered the most important:

1. Museum staff must be enthusiastic about the product in order to promote it to visitors.
2. Content is the most important part of the Virtual Museum. It must be up to date, and divide the attention between the Information assistant and the museum objects.

These two guidelines should be kept in mind throughout the Virtual Museum.

Personal Information Assistant

The Personal Information Assistant assists, informs and entertains visitors during their visit. PIA is unique in that it offers:

- a complete package consisting of information assistants (devices), a content creation program, data-analysis program and website, which are all linked to each other;
- information assistants for both indoor and outdoor use;
- a combination of a pull-based information system, personal preferences and the actual location of the user;
- a Virtual Museum website on which the museum visit can be re-lived and expanded;
- the opportunity for visitor to add new information to the assistants and the website through the Virtual Museum;
- an explanation of the inner workings of the positioning systems for a better understanding and thus a better experience of the museum visit.

Concepts and interface designs for the Multimedia Guide were often tested with possible users during the process. At the end a demonstration was given at the TTH to show the product to stakeholders and to test it in a real museum setting. The demonstration pointed out that people are enthusiastic about the Multimedia Guide and are able to use it. With PIA, visitors orient themselves by mapping the objects they see in their surrounding with the objects on the electronic map. The multimedia guide enhances the experience; this can be inferred from the test persons' reactions on the demonstration at TTH. If the attention is well divided between the PDA, the museum objects and surrounding can not be concluded based on the test results.

No existing research was available for some of the core concepts PIA relies on, like a metaphor for the bookmark button, the size of touchscreen buttons for finger use, and color schemes for outdoor screens. Bookmarking has been found to be the best tool to bridge between the museum visit and after the visit, to extend and relive the museum experience. A bookmark test has been conducted, which concluded saving is an appropriate metaphor and a picture of a floppy disk a suitable icon for the bookmark button. The minimal touchscreen button size has been determined by calculating the area of a finger that touches the screen when pressing a button, which is at least 13x13 mm. It has also been determined which colors are best distinguishable when used outdoors, specifically in direct sunlight: blue text on a yellow or white background is the best option. Furthermore, a rapid prototyping method for use with PDAs has been called digitized paper prototyping has been described to fill the gap between paper prototypes and programmed prototypes.

The Virtual Circle to involve visitors

A Multimedia Guide enhances the museum visit, but to involve visitors more is needed. By creating a Virtual Circle-chain as described in section 5.2, or at least the initial aspects of it, the museum can create bonding with its visitors and involve visitors. The Virtual Circle can also help museums with some of their most important tasks: attracting visitors, and archiving and disclosure of cultural heritage. To create bonding between visitors and museum the Multimedia Guide is not the most important product but it can attract visitors to the museum. The next step is to assure that people leave their email address and follow up on their visit on the museum website. This connection is made by the bookmark tool.

How to start building a Virtual Museum

A museum that wants to create a Virtual Museum has to start with an enthusiastic basis of staff members and volunteers. The second step is to create content, because the Virtual Museum needs a fruitful ground with interesting and entertaining content. The content can be used to fill a Multimedia Guide that uses a simple numberpad to access object information.

The fourth step is a website that extends the museum visit to before and after the visit. This step includes linking the museum visit to before and after: the bookmark tool has to be available and a registration terminal where users can fill in their email address. With this fourth step the Virtual Circle-chain is created.

After achieving this, it becomes important to have a back-end system to manage and create the content to keep the Virtual Museum up to date and to analyze visitors' behavior to learn how to

improve the experience (step five). The sixth step can be to add location based services to the Multimedia Guide and to work with a map based interface. This will give users the opportunity to navigate and orientate with the Guide and the museum receives more useful data to analyze visitors' behavior.

The following step will be to add a Front-desk with a rack solution in which the PDAs can be recharged and updated more easily. In the very last step, number eight, extra functions are added. These functions build on the location based services added in step six to make it possible to look up the position of co-visitors, receiving notifications of the museum, ask questions to staff members and other advanced functionality.

Advantages of the Virtual Museum

The advantages of the Virtual Museum for the *visitor* are that it provides them with multimedia information aimed at their interests and that they are in control of the information they consume. In the museum, PIA helps them in finding locations and following tours. The Virtual Museum provides the *museum* with statistics about visitor behavior, the way they move trough the museum and which object and information they find interesting. With the Virtual Museum, the *city* of Hengelo gains an innovative museum with which they can attract more tourist to the city and which can connect and reach out to other touristic attractions of the city.

11.1 Recommendations

Research and user tests have resulted in guidelines and specification that are used in this project, and can also be of great value for similar projects. For the parts that are not fully designed in this report, guidelines and requirements are given to make sure that these parts will fit into the Virtual Museum. The guidelines can be found in Appendix H, while the requirements can be found in Chapter 4. The two guidelines mentioned in the conclusion above, "museum staff must be enthusiastic about the product in order to promote it to visitors" and "content is the most important part of the Virtual Museum" should be kept in mind throughout the Virtual Museum in order to make it a success.

The large amounts of steel at the TTH interfere with the used **indoor positioning technologies**, making the positioning less accurate. It should be tested if other positioning technologies work better for the TTH. If no satisfying combination of positioning technologies can be found, PIA should use the numberpad instead of a map.

For the **Multimedia Guide,** more research should be done as soon as high quality content is available to reveal the answers on al the initial demonstration questions. Visited state feedback (section 9.6.2) and low battery state feedback (section 9.67) must be added to the interface of the Multimedia Guide so it will comply to the guidelines. The Guide's map could also show when an object is has been visited or bookmarked. This particular problem needs more research. Besides explaining the bookmark function in the introduction movie, it would also be helpful to give a textual message as feedback when the user uses the bookmark button for the first time.

For TTH the focus should be on the content**,** and for SIS on the Virtual Museum foundations, like the CMS, analysis tool and the Virtual Museum's website. When TTH starts building its own Virtual Museum it should follow the steps as described above: How to start building a Virtual Museum.

For the **content framework** more research should be done to complement the guidelines for attention division, audio and text with guidelines about the contents of the content.

For the **website** a prototype should be build based on the lists with functionality and concepts given in this thesis. With this prototype user test can be conducted for the phases before and after the museum visit.

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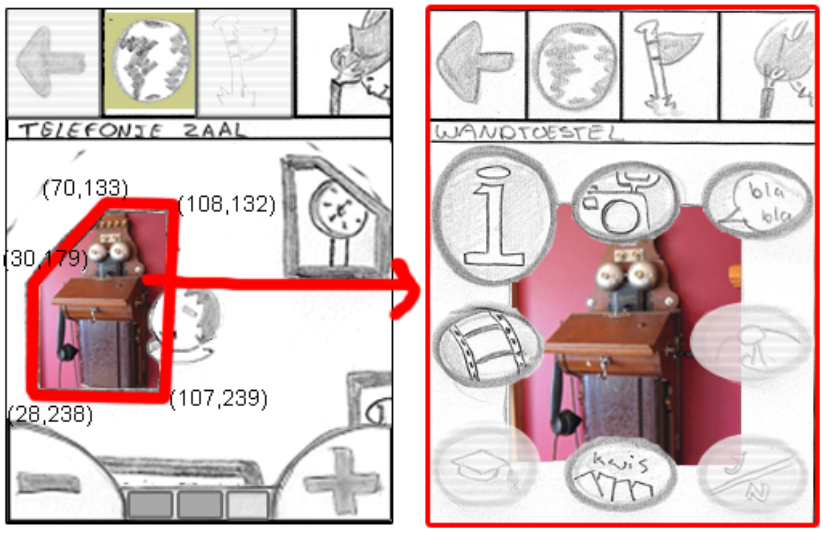
Appendices

Appendix A: How to create digitized paper prototypes

How to create a digitized paper prototype. To create a digitized paper prototype, the following procedure is used:

(1) Scan all pages of the paper prototype and make . png or other images from it.

(2) Take note of the coordinates of all buttons, which can be viewed by opening the scans in, for example, Adobe Photoshop or Microsoft Paint. Buttons can be of a rectangle, polygon or circular form. The figure below shows the coordinates of a polygon form, when this polygon form is pressed in the digitized prototype the picture on the right had to show on screen.



home kaart.png object 1 menu.png

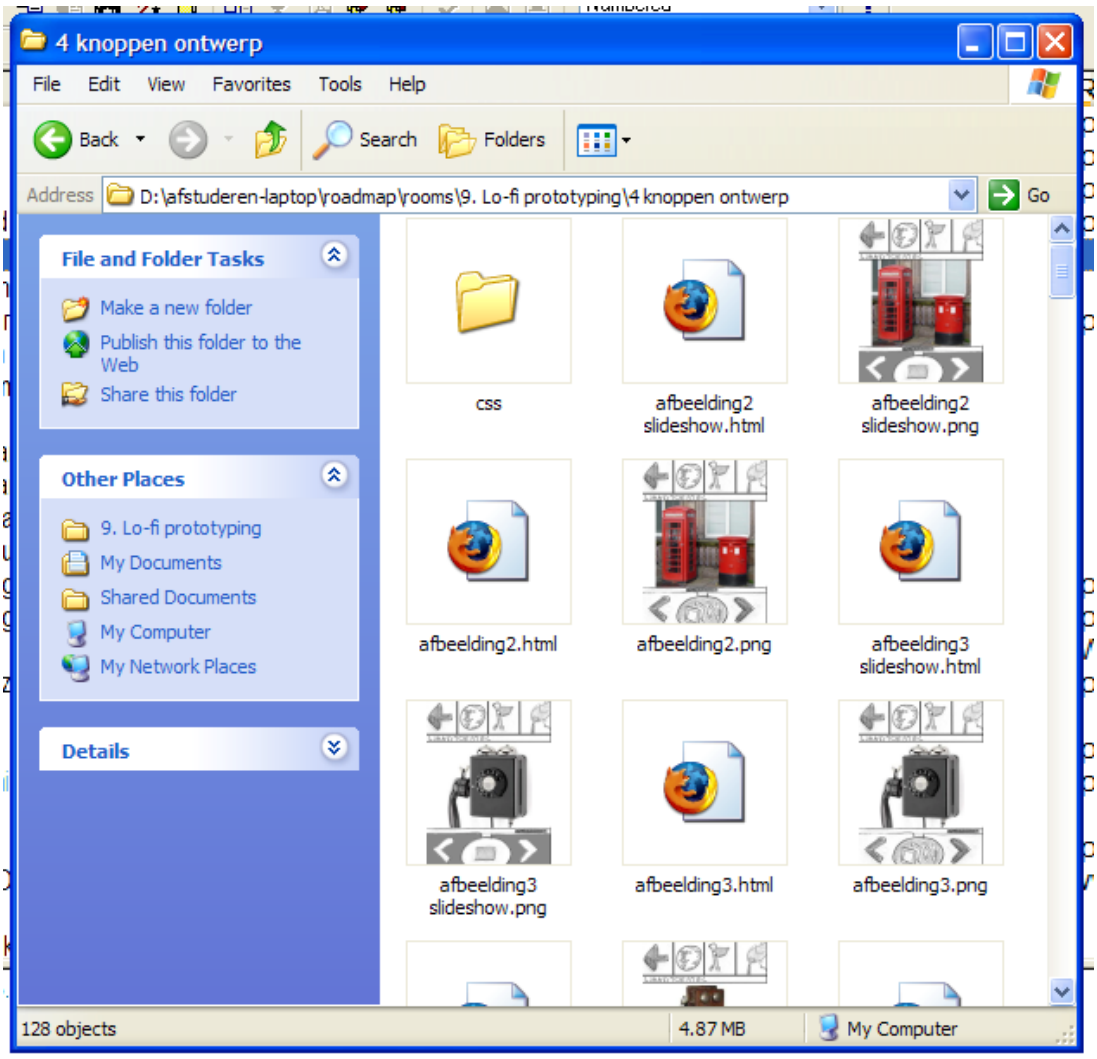
(3) Open a text editor to write a .html page with the code that is displayed below. The button coordinates are used to describe the buttons size and position. Every button links to another .html file that contains the .png with the image of the screen to which the button should lead the user to.

```
<html>
<head>
<meta http-equiv="Content-Type" content="text/html; charset=UTF-8">
<title>Untitled Document</title>
<style type="text/css">
@import url("./css/style.css");
</style>
</head>
<body onload="init()">
  <img src="./home kaart.png" alt="bg" width="240" height="320" border="0" usemap="#link">
<map name="link">
<area shape="polygon" alt="" coords="107,239,108,132,70,133,30,179,28,238" href="object1.html" target="_self" />
</map>
</body>
</html>
```

(4) Open a text editor, paste the following code and save it as style.css

```
body {
	background-color: #FFF;
	height: 100%;
	margin: 0;
	overflow: hidden;
	padding: 0;
	width: 100%;
}
```

(5) The folder with all .png and .html files can now be copied to a PDA. Just click on a .html file and it will open in the PDAs browser.



Appendix B: Extended Market Research

Extended market research

Extensive descriptions and for the following systems:

Product name	Company	Museum/facility
GuideID	Guide ID	Museum Boijmans Van Beuningen, Rotterdam CODA Museum, Apeldoorn
Antenna Audio	Antenna Audio	Van Gogh Museum, Amsterdam Tate Modern, London
VUEguide	Ubiquity Interactive	Museum of Anthropology (MOA), Vancouver
SCALEX	University of Applied Sciences FH Joanneum, Graz	Zentrum für Kunst und Medientechnologie (ZKM), Karlsruhe
Camineo	Camineo	Ecomare, center for Wadden and North Sea, Texel Island
Narrator	Touchport	Museum Vleeshuis, Antwerp
Droombeek	Droombeek foundation	the district Roombeek, Enschede
Codex	Hootchie Cootchie Mediacollectief	the district Delfshaven, Rotterdam
GUIDE	University of Lancaster	City of Lancaster

GuideID

The GuideID multimedia museumguide is a product of the Dutch company GuideID. Visitors are equipped with a PDA, carried around the neck, that gives multimedia information about objects in the exhibition. The system comes with a box to charge and update the PDAs, a Content Management System, infrared tags and a Management Information System [3]. Several museums and other organizations use or have used the GuideID system. Information about the GuideID has been collected by testing the system in two museums, the CODA museum and the Boijmans van Beuningen. Furthermore, three museums (Groninger Museum, Kröller-Müller Museum and Netherlands Architecture Institute), a zoo (Wissel Zoo, Epe) and a photo exhibition organization (World Press Photo) that have used the device in the past have been asked for their opinion.

Technology: PDAs and infrared tags.

Context-awareness: GuideID does not make use of positioning technology but is aware of his context if the user scans an infrared tag with the GuideID.

Media: The GuideID in the CODA museum presented text, audio, video and pictures. The GuideID in the Boijmans Van Beuningen museum behaved more like an audioguide with a picture now and then.

The user interface: The Boijmans user interface is triggered when holding the PDA before an infrared tag. The guide starts with narrating some basic information about the painting. After the introduction the user can choose between topics with extra information. To activate a topic, the user has to touch the corresponding software button with his finger.

The CODA guide is much larger and the interface is rotated by 90 degrees. Information about objects can be accessed by touching the corresponding number with a wooden stylus on the number pad. The information is presented in text with additional photos. The texts are long; they can be scrolled by touching the up en down buttons in the interface. When the screen is touched while a movie is playing, the control buttons (play, stop, rewind, volume up, volume down) become visible.

Attention division: By adjusting the texts presented on the GuideID device, the Kröller Müller museum ensured that the user would not be focused too much on the PDA. The GuideID describes for example a certain detail of a painting and tells the user where to look on the painting; by doing this the users attention is consciously guided.

Personalization: Steven Kolsteren, head education at the Groninger museum, told that users could choose one of 3 tours through the museum and that tours were available in 4 languages.

Before and after the visit: None of seven organizations that are visited or contacted used the GuideID as a tool to extend the experience before or after the visit. According to the GuideID website features that can accomplish this are non-standard.

Visitor experiences: **Groninger Museum**

A small study from the Groninger Museum concluded visitors were very enthusiastic; they specially liked the ability to choose which information to view

For audio the PDA speakers were used, which was sometimes aggravating when people with multimedia guides stood together confusing or disrupting the multimedia tour.

Kröller Müller Museum

87% of the Kröller Müller Museum (KMM) visitors held the opinion that the device improved their museum experience and that the texts were satisfying according to Drs. Herman Tibosch of KMM.

CODA Museum, visited by Marieke Steltenpool

The CODA guide is used for an exhibition that is already filled with multimedia. The multimedia guide provides an overload on multimedia information here. The presented information has to be read and the texts are rather long; therefore, it did not provide added value to the museum visit.

Boijmans van Beuningen Museum, visited by Karin Dijkstra, Sebastiaan Frehe and Marieke Steltenpool

The PDA of the Boijmans Van Beuningen museum was more like an audioguide with a picture every now and then. The information was very interesting to listen to. Karin's opinion was that the guide really adds something to the museum experience and that is easier to listen to the texts than it is to read them. Sebastiaan is very enthusiastic about the information and shared the information he received via the guide with the rest of the group. We all talked to each other about information we got from the guide.

NAi, visited by Karin Dijkstra, Sebastiaan Frehe and Marieke Steltenpool

The GuideID from the NAi can not be rent because the museum received a lot of complains about it. The problem is the room the multimedia guide is aimed at is a dark room to protect the drawings. Because of this, people don't what to stay in the room longer than approximately 10 minutes.

Maintenance: The devices can be placed into the BaseStation, a lightweight 'flight case' storing 16 PDAs for updates and recharging [3]. A CMS system allows the museum to create and manage content and to compose tours. Updating must be done on the main computer. The content is then sent to the PDA's; this can take up an hour. Nevertheless the Groninger Museum system became outdated.

Data analysis: According to the GuideID website their product generates management information that indicates which objects are examined most, how long a visitor is in the museum and more [3]. However, none of the seven museums have used this feature.

Experiences of museums: **World Press Photo.**

World Press Photo used the multimedia guide to tell the stories behind the photos and to give information about the photographer. At the World Press Photo exhibition of 2005 in Amsterdam and Groningen, only 114 of the 10.000 visitors used the multimedia guide. Visitors had to pay 2 euro for the guide, but according to Femke van der Valk from WPP this was not the reason people did use it. She thinks that, after all, visitors just want to look at the photographs and do not want the distraction of extra information.

Groninger Museum

The Groninger Museum chose to use a multimedia guide in parallel to the existing audio-tour, because comparisons between objects are occasionally made and they have a lot to tell about the architecture of the museum building. Steven Kolsteren of the Groninger Museum says museums need to have a desk with trained staff members for a multimedia tour, so that they do not just hand over the PDA but also provide an explanation. The desk must also ensure publicity and marketing.

The GuideID at the Groninger Museum had some initial problems, mainly of technical nature. The PDAs were also equipped with too many buttons, not all of which had a function

The devices of the Groninger Museum did not have an on/off button; they were turned on by using the reset button. Visitors could not press the reset button.

The weakest link counts, if users have to walk back to the counter halfway through the tour because the battery is empty, they will quickly abandon it.

Kröller Müller museum

The Kröller Müller museum held a pilot; they are still very enthusiastic about that pilot. They would like to install the system, but there is no desk in the museum for the device hand-out.

Antenna Audio

The Dutch Van Gogh museum and London's Tate Modern use a multimedia guide by the English company Antenna Audio, the leading provider of audioguides. The multimedia guide is an application on a PDA that can be carried in the hand or with a cord around the neck and gives multimedia information about objects in the exhibition. Information about the multimedia guide has been collected by testing the system in The Van Gogh museum, which uses both the audio and multimedia guide from Antenna Audio. And by research papers and other published information about the Tate Multimedia guide.

Technology: PDAs.

Context-awareness: Antenna Audio does not make use of positioning technology.

Media: The Antenna audio guides present audio, photos, pictures, interactive elements and movies. Pictures can be zoomed.

The user interface: Information about the paintings in the Van Gogh guide is accessed when the user touches a picture of a painting on the screen. After an introduction, the user is redirected to a timeline and icons appear around the artwork.

Tate modern chose for a clear and uncluttered screen, with icons that are also used on the Web. When an object's number is typed in or an object is selected on the map the information about the object becomes visible.

Attention division: The Van Gogh's guide directs a user's attention to elements of the painting, by saying for example: "Look well to…", to divide the users' attention between PDA and the painting. According to the Tate Website the information on the Tate Modern guide are provided in short segments, so that the viewer's attention is consistently drawn back to the artwork on display [47].

Personalization: The Van Gogh guide is available in Dutch and English. Tate Modern provides three different tours to serve different user groups. Tate Moderns Collection tour is linked to their CMS system, in the future this information can be filtered based on the users age, interests or previous choices to provide customized tours [13].

Before and after the visit: Users of the Tate modern guide can email information home after filling in their email address. The Van Gogh museum has no options to extend the experience.

Visitor experiences: **Van Gogh, visited by Marieke Steltenpool**

The start page of The Van Gogh guide is full of colorful graphics. These graphics are hard to distinguish from the background, but turned out to be the buttons to reach object information. The type of information hidden behind these graphics is not clear

to the user, because every piece of information has a unique button design. Graphics that can be clicked are generally outlined by a dashed line but not consistently. The help function and home button are not reachable from every page

The guide reacts very slowly; it can take up to 3 seconds to react to a command. Interface elements that shove in are therefore very irritating because it is shoving in very slowly and the user is waiting until he can use the element.

The audio is very pleasant to listen to.

According to Melanie Verhoeven of the museums education department, an intuitive interface is chosen to let the users discover the elements in the interface by themselves. She does not know if the users really discover everything.

Tate Modern

Gillian Wilson from Tate Modern writes that different media types were used during the first pilot without giving the user clues about what to expect. It was found visitors want to experience the tour in a coherent way [13].

A 4 month during evaluation of the Highlight tour in 2003/2004 pointed out that users spent 70 minutes with the guide on average. Almost all users thought the Highlight tour had improved their visit and most users thought they had stayed longer in the gallery than they would have done without the guide [13]. A survey conducted in 2002 on the first pilot of the Tate Modern Multimedia guide indicated that slightly more than half of the users found the guide easy to use, while the others found the guide difficult to use [48].

Maintenance: The Van Gogh's devices are charged by putting them into a charge box. Colored LEDs give information about the charge state of each device. Updating is done by Antenna Audio, not by the museums themselves.

Data analysis: No information about visitor behavior has been obtained.

Experiences of museums: **Van Gogh Museum**

According to Melanie Verhoeven, an advantage of the multimedia guide is that it can display objects that are related to each other.

The ladies behind the Antenna Audio counter in the Van Gogh museum are not very willing to rent the multimedia guide to visitors. They lose much time in explaining the guide to users, and afterwards receive complains because the device reacts very slowly to user input. Only 20 artworks are included in the device and it is outdated.

VUEguide

The VUEguide is a product of the Canadian company Ubiquity Interactive. The VUEguide devices are PDAs with an extra large battery pack and are packed in a custom casing. They respond to infrared signals emitted location beacons placed throughout the main galleries when the device is pointed at

the tags. The system from Ubiquity Interactive was installed at Vancouver's Museum of Anthropology (MOA) from the Spring of 2005 through to Fall 2007. Information on the VUEguide has been collected by using press releases and papers and by email contact with Jennifer Webb, Communications Manager at MOA and Leora Kornfeld, principal of Ubiquity Interactive.

Technology: PDAs and infrared tags

Context-awareness: The VUEguide used at MOA does not use of positioning technologies, but is aware of his location if the user scans an infrared tag.

Media: High quality full screen video, audio, graphics, flash animations, 3D models and interactive panoramas.

The user interface: When an infrared beacon pertains to a group of objects, the user has to choose which object to explore by clicking the object's picture. When an object is chosen, the device displays information about the object together with pictures and links to other pages with more information. Objects can also be opened by using a three dimensional map of the museum in which the user can scroll to different areas of the museum. The device also includes a three dimensional image of a carving that can be rotated.

The interface makes use of 'forward' and 'back' buttons and users can send the page they are looking at to a friend, by pointing at the friend's device and tapping a button [49].

Attention division: Because of the high quality videos on the device, people look at the screen instead of to the museum object.

Personalization: The guide can not be personalized.

Before and after the visit: The intention is to add a bookmark option to the MOA VUEguide in the future, so that users can bookmark content and access it later on the Museum's website [50].

Visitor experiences: **MOA**

A hundred objects are presented in the VUEguide, good for 2 hours edutainment, but on average a tour ranges from 35 to 45 minutes [51].

A student of the Evergreen State College

The first VUEguide this student received did not turn on at all, the second froze when playing with a three-dimensional object and the third also froze eventually. However, the student found the VUEguide to be a great addition to his museum experience, and recommends it to any museum visitor seeking to learn as much as possible during their visit [49].

Maintenance: The devices are recharged by plugging them into their adapters. The museum itself cannot update the content, although Ubiquity Interactive developed software for such purpose. Their reason for not making this software available to the museum is that the system and interactions are very complex; they believe that anyone without technical experience would probably do more harm than good to the content and layout.

Data analysis: All user actions on the devices are recorded, but MOA has not yet used this information.

Experiences of museums: **Jennifer Webb, communications manager of MOA**

The VUEguide is very popular, in high season (summer) 13-15 units are rented per day on average, whereas in the slower season 5-6 are rent per day.

"We are very proud here at MOA to have had the opportunity of working with Ubiquity to bring this technology - and enhanced information about the collections - to our audiences. Staff, students, faculty, and volunteers here continue to be impressed by the amount of information we managed to install on such a small device, and by the positive response we received from our visitors from the very beginning. It is understood that this iteration of the VUEguide is on the very cutting edge of new ways to deliver information in the galleries, and that of course there will be bugs. It is also understood that the potential for adding to existing content is very much alive. " (Jennifer Webb)

SCALEX

SCALEX is a scalable exhibition server with which museums can publish digital content in exhibitions. It consists of several components: a Knowledge Editor, a Storyliner, a Player and a Profiler [4]. The SCALEX project was supported by the European Commission. The project was carried out jointly by 11 institutions from 5 countries, coordinated by the department of Information-Design at the University of Applied Sciences FH Joanneum, Graz, Austria [2]. Information about the SCALEX project has been collected from papers and by email contact with DI Jochen Martin from FH Joanneum Gesellschaft mbH and Miriam Stürner from Zentrum für Kunst und Medientechnologie (ZKM) in Karlsruhe.

Technology: Different presentation device can be used, like PDAs and kiosks. These devices communicate using the SCALEX messaging system. SCALEX also uses RFID and infrared technologies.

Context-awareness: Location sensing techniques like RFID readers and infrared sensors can be used to create context-awareness [4].

Media: Different media types.

The user interface: PDAs and infrared beacons are used to interact with the SCALEX server. For the PDAs an interface was designed that can be manipulated by visitors with their fingers.

Attention division: not studied.

Personalization: The digital media presented to a visitor is directly coupled to the visitor's age, language and interests. Visitors also have the ability choose storylines (tours) and to browse additional content. During a first test at the Technical Museum Vienna users could fill in their profile by making selections in the dialog. Sliders are used to set profile values and the visitor can choose which parameters are most important. SCALEX can also recognize user behavior and, based on that, present customized content[4].

Before and after the visit: Nothing is done to extend the experience.

Visitor experiences: not studied

Maintenance: not studied

Data analysis: SCALEX PDAs deliver information that varies with the history of the visit (Miriam Stürner from ZKM).

Experiences of museums: Problems that occurred during the different tests were related to stability of the technology and the suitability of the PDAs as client devices (Jochen Martin from FH Joanneum Gesellschaft mbH).

The SCALEX information system was tested in the Zentrum für Kunst und Medientechnologie (ZKM) in Karlsruhe. According to Miriam Stürner from ZKM, the SCALEX software is substantially helpful in bridging the gap between the current and the next generation of visitor support systems. It has proven to be able to:

1. connect a server with presentation devices and connect presentation devices amongst themselves;
2. connect a server to different devices simultaneously;
3. deliver (i.e. publish and play) information that varies with the history of the visit;
4. support visitor profiling both in editing information as in playing it.

Camineo

Ecomare, the center for wadden and North Sea on Texel Island, makes use of an outdoor multimedia guides from the French company Camineo to provide visitors with the opportunity to discover the area in a fun and educational way. The system has been developed by Ecomare, Geodan and Camineo and funded with European Innovation subsidies [5]. The visitor devices are PDAs with a keycord. The museum can create and update content itself using the Camineo CMS. Information about the Camineo guide at Ecomare has been gathered by testing the system and interviewing Oscar Bos of Ecomare.

Technology: PDAs and GPS technology.

Context-awareness: Ecomare's Camineo guide uses GPS as positioning technology, so the guides are constantly aware of their location.

Media: Text, pictures and audio.

The user interface: The start page is a map of Dune Park, with a blue dot on the current location of the user. A back button is placed in the top-right corner. Via the drop-down menu option 'Go to' the index can be reached. In the index three categories can be chosen: landscape, fauna or flora. The corresponding icons are also visible on the map. When the user chooses an object on the index page or reaches a particular place in the Dune Park, a cuckoo sound is played and the information can be read of the screen. If the information is not triggered when standing on the right spot, the icon can also be

clicked. This only works when the user is in the vicinity of the icon, in order to encourage the visitor to really walk through the park.

Attention division: The content of the Camineo guide points the user to things that can be seen in his surrounding. Sometimes the content is split up between two pages, one with a question and the other with the answer. This encourages the user to investigate the presented subject and when there is more than one user, to discuss the question.

Personalization: The guide from Ecomare cannot be personalized but Ecomare is working on tours for special user groups like schoolchildren.

Before and after the visit: Nothing is done to extend the experience.

Visitor experiences: **Paul Uithol and Marieke Steltenpool, guided through Dune Park.**

The first guide freezes while starting up. The guide comes with a stylus, which is really required to push the tiny buttons and icons. The top of the screen provides a menu, with contains an icon with 3 circles which turns out to be the 'back to the map' button. In the top right corner a back button is placed, which we would expect in the top left corner, because that is a common place in web browsers

The device is not protected against curious visitors; we could easily dismount the battery or copy content.

The Dune Park tour is very interesting and entertaining, especially the questions that can be discussed. We walked the route in the opposite direction accidentally. When we almost finished the tour, we got a lot of cuckoo sounds notifying us of information. This was getting Annoying.

Maintenance: The content needs intensive maintenance because information about the flora and fauna changes depending on the season, as the landscape changes. For this purpose a CMS system from Camineo is used. The guides are recharged and updated by plugging them into their adapters.

Data analysis: No information about visitor behavior is obtained.

Experiences of museums: In summer and autumn 2005 more than 500 people participated in two user tests. Most people were positive about the system in general and found the handheld easy to use. The interaction with the device was graded as fine and the maps shown for orientation were found to be okay, although the speed of map actions could be faster. The visibility of the screen in the outdoors was acceptable. Users found the information to be interesting, and thought it made their walk more interesting. However, the 35 information events on the 1 km route were a bit too much.

Narrator

Museum Vleeshuis in Antwerp Belgium provides every visitor with a multimedia tour on a PDA, called the "Narrator". Behind the counter, a wall full of PDAs are waiting for visitors. A screen on the counter gives information about the device. The platform, Touchport, provides tools to create and update

content over the internet and options to personalize a tour. Information on this system has been collected by testing the Narrator and questioning counter staff.

Technology: PDAs.

Context-awareness: The Narrator does not use positioning technology.

Media: The device presents text, spoken text fragments, music fragments, short videos and animations. For most objects extra pictures are included in the Narrator.

The user interface: The device starts with the numberpad as beginning page. In a previous version of the interface, visitors had to choose a theme, then a sub-theme, and were presented with three top pieces before they could view a list of all objects. This navigation was confusing, and caused people to get lost.

When an object's number is entered and the button labeled 'object' is pressed, a caption and a short piece of text about the object are displayed. Below the text, buttons to pictures, audio and movies related to the object are visible.

When listening to audio the volume can be adapted, paused and an indicator of the fragments duration is shown

The buttons are designed to be manipulated with a stylus, but can be operated with small fingers (although buttons in the corner are difficult because of a sharp metal plate attached to the front of the device).

When an object's number is entered on the numberpad and the button labeled 'sight' is pressed, the PDA shows a map which highlights the objects position.

Attention division: When the user enters a new theme a small introduction is given in spoken text. The rest of the fragments have to be read, so the user looks at the screen instead of the object. None of the texts read directed the user to watch the museum object.

Personalization: The user can choose from multiple languages.

Before and after the visit: The Vleeshuis' narrator was designed so that users could bookmark objects of interest. But at the moment this option is not available, since the step where users fill in their email-addresses is skipped.

Visitor experiences: One of the staff members picks a guide out of a box and starts it then lays it away to grab a new one, because the first one did not seem to work. When I receive the guide, the screen shows a numberpad. The staff member explains that I have to type in a corresponding object number and then press the 'object' button.

I try to bookmark the first object by clicking on the 'envelope' button but receive an error message and script code appears in my screen. The application freezes and I have to go back to the counter. One of the staff members tells me that I should not press any buttons when the application is loading because it will cause the guide to freeze. The reason for the error is that no email-address was entered. This step is normally skipped, because it was giving problems.

The length of the text for an object differs highly. Sometimes, the information inside the guide is merely the objects name, while more information is available on the sign

next to the object. Most of the given information appears a bit superficial, but when the texts are longer I notice that I do not really read all of it.

The guide contains a lot of music fragments, most of the displayed objects are musical instruments. The user is in control of the audio volume, especially handy because actual musicians play in this museum every now and then. The audio fragments from videos that are shown on screens mounted at the wall can be synchronized to the guide by entering the corresponding number.

Maintenance: The museum itself is in control of the Narrator's content. The devices are placed in boxes to be updated and recharged.

Data analysis: Initially, visitors had to fill in some personal data before starting the museum tour. For example, an e-mail address was requested so bookmarked objects could be emailed afterwards. This also enabled the museum to see which target groups (or were not) reached. However, to prevent problems of people being lost in the interface, this personal data is not filled in anymore.

Experiences of museums: In the initial interface visitors were quickly lost and had to come back often to the counter with questions, to overcome that the devices now start with the numberpad as the start page.

Droombeek

The Droombeek foundation strives to stimulate communication in and about the district Roombeek in Enschede, and preserving the past, present and future of the district and its inhabitants. For this purpose a platform has been developed consisting of an interactive website and handheld guides which provide a tour through the Roombeek district. Information about the handheld guides is gathered by testing the tour and by interviewing Peter Dubois of the Droombeek foundation.

Technology: PDAs and GPS technology.

Context-awareness: The guides use GPS as positioning technology, so the guides are constantly aware of their location.

Media: The guides contains text, audio, video and pictures.

The user interface: The main page of the Droombeek interface is a map. Information items on the map can be accessed by walking towards them. The software buttons on the guide are rather small, so a stylus is provided. The user can scroll through the texts with the scrollbar. User can mark their current location to leave a story; this story can be composed with the help of the onscreen keyboard and can later be finished on the Droombeek's website

Attention division: The guide shows pictures of how the location where the user is currently standing looked in the past or is planned to look like in the future. This might result in the user observing his surroundings in more detail. The videos draw all attention to the guide instead, of his surroundings.

Personalization: One or more of the following topics can be selected: Daily life, Fireworks catastrophe, Textile and other industry, Art and culture and Architecture.

Before and after the visit: The Droombeek website provides possibilities to extend the Roombeek tour experience to before and after the walk. All information can be read on this website; people can reply to stories and can add their own stories and photographs. If you marked points of interests, you can finish writing the stories here.

Visitor experiences: Because of the sun it was difficult to watch the movies on the PDA. They could only be seen when standing in the shadow and were very interesting. The textual information was less engaging.

Maintenance: Handing the device over to visitors and recharging them done facilitated at the Rijksmuseum Twenthe in Enschede. The Droombeek foundation updates the devices with new information provided by visitors on the Droombeek website. The software on the devices is written by the Telematica Instituut and runs only on the PDA currently used

Data analysis: No information about visitor behavior is obtained.

Experiences of museums: not studied

Codex

Codex Delfshaven is a project from Hootchie Cootchie Mediacollectief. Visitors receive a PDA with headset. The PDA shows a graphical map of the district Delfshaven. A separate satellite map is provided on paper for orientation and navigation. This paper map is full of red dots, spots were audio fragments, and sometimes, pictures are available. Information about the Codex handheld has been collected by testing it and asking questions to the persons that gives out the devices.

Technology: PDAs and GPS technology

Context-awareness: The Codex PDA uses GPS to locate the user, so they are constantly aware of the location.

Media: The guide presents audio and pictures.

The user interface: Before starting, the PDA should have a GPS fix. As soon as the GPS has a fix, a button with 'Start the tour' is shown on the screen. The tour starts with an introduction by the character mister Campfens and two young girls. When the graphical map on the screen is touched it switches to pictures about the current location, if available. When the user gets in the vicinity of a story, Campfens starts speaking.

Attention division: Most of the information is in audio fragments, so the user does not have to look at the screen. When pictures are available, the user watches the screen but might look around afterwards to see where the picture fits in his surroundings.

Personalization: The user can choose how to walk through Delfshaven, there is no predefined route.

Before and after the visit: The experience can not be extended to before or after walking the Codex tour.

Visitor experiences: Karin Dijkstra, Sebastiaan Frehe, Marieke Steltenpool

After hearing the introduction a graphical map of the district is displayed. When touched it disappears, after clicking again the map reappears but is moved by 2 cm. The interface stays moved for 2 cm during the entire tour.

When we enter a POI, the character Campfens just starts talking through the headset Because this happens so suddenly, it frightens the user. The Codex guide characters like Campfens, who tell the stories, are found to be highly irritating and the stories themselves are also not very interesting.

Because the satellite map on paper, and the graphical map on the PDA do not look alike it is hard to figure out what the current position on the map is and which way to go. The graphical map does not show the red POI dots, so information is easily missed. Because of the sun, the screen is badly visible.

Maintenance: Recharging and giving out the handhelds is done at Hotel Stroom.

Data analysis: No information about visitor behavior is obtained.

Experiences of museums: Some of the devices do not start up, next to that there are some more problems with the devices. Hotel Stroom does nothing to generate publicity they only facilitate the handing over but the guides are nearly rent.

Some of the devices do not start up, along with some other problems with the devices. Hotel Stroom does nothing to generate publicity; they only facilitate the distribution but the guides are merely rent.

GUIDE

The GUIDE project from the University of Lancaster has developed a context-sensitive tourist handheld guide for outdoor use. During the project, the guides were available from the Lancaster City Council. Information is obtained through a research paper [6], the projects website [7] and email contact with Jane Silvester from the Lancaster City Council.

Technology: tablet PCs and WLAN technologies.

Context-awareness: A wireless network (WLAN) is used as positioning technology to calculate the user's location, so the guides are location-aware as long they stay in the centre of Lancaster.

Media: The guide presents text and pictures.

The user interface: Before starting, the visitor is asked to enter some personal details like name, interests and language. Then an intro screen is shown to the user with an explanation on what to do. With the GUIDE, users can retrieve information, navigate by using the city map, follow a tour, communicate with other visitors by sending text messages or book an accommodation.

Attention division: not studied

Personalization: Information is personalized by using the user's age, language and what he is interested in: Architecture, Maritime related information, Lancaster's history or

	Vegetarian food. When the user is creating his own tour, he can select the attractions he wishes to visit.
Before and after the visit:	There are no follow up options.
Visitor experiences:	not available
Maintenance:	The guides must be recharged and someone is in control of maintaining the information.
Data analysis:	No information about visitor behavior is obtained.
Experiences of museums:	Jane Silvester, Tourism & Marketing Officer of the Lancaster City Council:
	Several years ago, the Lancaster City Council was involved in the Guide project. The technology was quickly redundant and it was inappropriate to be used when wandering around the city. As an attraction it was ok, but it is probably more appropriate to download a podcast onto a handheld device to provide the same function.

Appendix C: User wants

The following list with user wants are formulated by the researchers from "The Australian Museum Audience Research Centre" [10].

Users want:

- active hands-on experiences;
- to be able to use all their senses;
- something to take away with them from their visit;
- staff on the floor to answer questions and bring the exhibition alive;

Users want to learn:

- about unfamiliar concepts and things by starting with familiar ones and then move to unfamiliar ones;
- while being in control of their own experiences and the amount and depth of information they access.

Users want exhibitions which:

- will help to learn them something new;
- may be touched;
- do not require too much reading;
- also consist of computer interactives that enhance the exhibition and are not just 'button-pressing';
- allow them to stand close to the objects;
- are well maintained and working at all times;
- encourage talking and sharing among the group.

Parents want child appropriate exhibitions which:

- allow children to learn in an enjoyable way;
- provide new experiences and insights;
- complement school-based learning;
- are interactive and allow them to touch and experiment;
- have minimal reading;
- are at an appropriate height;
- provide a sufficient number of installations to avoid queuing;
- cater for a range of ages and abilities; and
- keep parents entertained as well.

C.2 Question related to objects in TTH

A list with question related to objects in TTH. These questions will be useful when designing content and to decide in which categories the information has to be ordered. The questions are subtracted from interviews with three possible visitors of TTH.

Users want to know:

- if the machine is still operational;
- In which year the object was manufactured/build;
- technical specifications like capacity, efficiency and noise production of the machine and the amount of workers within a company.
- what the purpose of the object is, what kind of company it is.
- who invented the machine and which company manufactured it.
- from where the museum got the object and what its original purpose was;
- why is the machine no longer in use and what was it replaced with;
- how did this place look a 100 years ago?

Users want to see:

- the machines in action;
- old movies with people using the object;
- how the machine works;
- how the building looks from the inside.

Users have detailed question when they want to know:

- what the purpose of that little tap or that rail on the machine is;
- why that building only has windows just under the roof.

C.3 All things the product should and could

All things the product should and could as result of the user needs from *Chapter 3 User needs*.

These lists sum up al the things the Virtual Museum should and could, these things are the result of the user needs from Chapter 3. The lists can be used while designing the Virtual Museum.

In the list below all user needs that impact the Virtual Museum as a whole are translated into requirements.

The Virtual Museum should:

- attract tourists;
- conserve, publish and expand the collection of cultural heritage of the city;
- facilitate a place were people can drop their own stories, that can be used as content to the Information Assistant;
- create some kind of bond between visitors and the museum by sending directly addressed invitations based on a visitor's interests;
- present the Information Assistant directly at the entrance. When the device is handed over to the visitor, he must already be aware of its functions;
- create a visual uniformity of the Personal Information Assistant, the Virtual Museum and the Museum website.

The Virtual Museum should let the visitors:

- learn through an entertaining experience before, during and after a museum visit;
- bookmark interesting objects for later reviewing;
- stay informed;
- acquire information about exposed objects that is of interest for them;
- share the experience with family and friends;
- add their own photos and stories to the collection of cultural heritage;
- log in on a part of the museum website, whereupon they get access to their bookmarks;

The Virtual Museum could:

- offer the opportunity to fill in personal interests before the visit;
- offer combination activities to visitors;
- best offer the Information Assistant without asking for any extra charge.

The Back-end is the part of the Virtual Museum that provides the museum the information it wants to receive and accommodates the functions that the museum would want to be able to use.

The Back-end should:

- give insight into the experience that visitors have in the museum;
- collect information from the visitors.

The Back-end should be a helpful aid to:

- set up special school programs;
- update multi-language information;
- test and improve theories about museum visitors and the behavior of museum visitors;
- test and improve theories about the composition and placement of exhibitions and objects.

The Multimedia Guide is the product that the user take with them during the museum visit, and which provides them with personal context-aware multimedia .

The Multimedia Guide should:

- give low level information first and than move to more in depth information;
- contain animations to enhance the exhibition;
- bring objects nearby at which visitors can not stand close to;
- encourage talking and sharing between visitors of a group;
- be controlled by the user so that the user is in control of the amount and depth of the information he access;
- Provide information auditory and textual, letting the user choose;
- teach the user something new;
- let children learn in a way they enjoy;
- give children a new experience and new insights;
- contain information that complements school-based learning;
- be adjustable for a range of ages and abilities;
- be able to run on different kind of devices;
- provide the possibility to bookmark interesting objects for later reviewing;
- show the user what kind of information he can expect about an object.

The Multimedia Guide could:

- give the user something he can take home with him;
- show the user machines in action;
- show old movies with people using the object;
- show how the machine works;
- show how something looks form the inside.
- tell the user who invented the machine/company, when it was made and by who, what it purpose was, if it is still running and some technical specifications;
- tell the user how things have been changed through time like “How this place looked 100 years ago.” and “What machine came in replacement for the one that stands in the museum.”;
- be able to answer (detailed) questions.

C.4 Some ideas on user needs

The scenarios of use that were written use information about the user needs from Chapter 3 and the concept of the Virtual Museum of Chapter 5. From these scenarios some ideas about the wants of users are extracted, that can be very useful in the further development of the Virtual Museum.

Users might want:

- to know what the Information Assistant is, before using it;
- a device that fit their needs best, this might mean that they want a device that is bigger or lighter than a PDA;
- to have the flexibility to fill in their personal interests before the actual visit;
- to be in control of the amount of time they spend on the introduction and on personalizing the Assistant;
- to be able to read the text that is presented to them, the font size must be sufficient or adaptable;
- to know what kind of information there is available about an object;
- to interact with the objects in the museum and not only with the Information Assistant;
- to be able to freely move around when sharing a device;
- to combine their trip to the museum with other activities.
- to look at the text labels, the current presentation of information in the museum;
- to fill in there interests or and get a selection of the available information;
- to get all the information that is available about an object;
- to be informed if there is a new exhibition that suits their interests;
- to share related stories about object/factories/time periods.

Appendix D: Scenarios

D.1 Scenario 1: Opa Fred (78), moeder Vera (43), vader Ton (45), Patrick (16) en Eva (11).

Website, voor bezoek

Eva speelt op de computer het online spel 'de energiecirkel'; een game op de website van Techniekmuseum het HEIM in Hengelo. Spelenderwijs leert ze over het opwekken van energie en over de opwarming van de aarde. 's Avonds aan het avondeten vertelt ze dat ze een gave nieuwe site gevonden heeft en nu alles weet over energie. Vera, die het mateloos irriteert dat haar kinderen zoveel computerspelletjes spelen, merkt op dat ze blijkbaar iets geleerd heeft door het spelen van een online game. Na het eten kijkt ze mee met Eva. Als Eva slaapt kijken Ton en Vera samen op de site en zien al gauw dat de spelletjes bij een museum in Hengelo horen. Ton vindt dat ze daar maar eens langs moeten gaan, hij probeert al tijden zijn zoon Patrick te interesseren in techniek, maar Patrick vindt niets leuk en heeft ook nog geen idee wat hij wil studeren. Vera roept Patrick en vraagt hem of hij dit weekend mee wil naar een technisch museum. Patrick haalt zijn neus er voor op: Welke idioot gaat er nou naar een museum!

Als Patrick een uur later achter de computer gaat zitten staat de HEIM site nog open. De 3D afbeelding van het gebouw trekt zijn aandacht; hij merkt dat er van alles zichtbaar wordt als hij de muis erover beweegt. Hij klikt op een etage en het beeld draait nu 90 graden. Een plattegrond van de etage wordt nu zichtbaar. Op de plattegrond staat aangegeven wat er geëxposeerd wordt. Hij klikt op stoommachines en wordt overdonderd met filmpjes en foto's van grote machines. 'Lauwe shit', denkt Patrick.

Maar nog steeds voelt hij er niets voor om rond te gaan lopen in een museum. Na een tijdje gesurft te hebben merkt hij dat zijn route in het virtuele museum gevolgd wordt en dat er in het echte museum ook iets gedaan wordt met het volgen van posities. Dat klinkt wel gaaf. Bij binnenkomst in het museum krijg je volgens de website een PDA waarop je gedurende het bezoek informatie krijgt aangereikt op basis van wie je bent en waar je bent. Patrick komt op de website een voorbeeldje tegen van hoe dit in zijn werk gaat. Een jonge vrouw staat naast een maquette van een rietsuikerinstallate. Op het scherm in haar hand ziet ze waar deze centrale staat in Indonesië en hoe deze werkt.

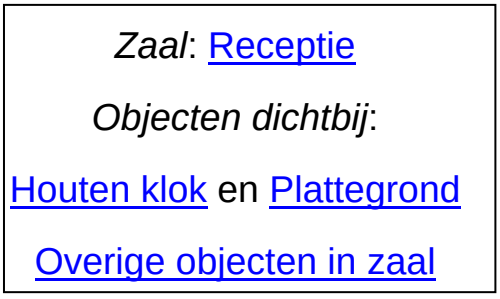
De volgende dag aan het avondeten oppert Vera nogmaals het idee om dit weekend naar het techniekmuseum te gaan. Eva is gelijk enthousiast, ze heeft op de site gezien dat er veel te doen is en dat er veel kinderen komen. Patrick geeft toe dat het misschien toch wel iets is, maar o wee als het net zo saai wordt als vorig jaar toen hij mee moest naar een museum.

Na het eten belt Vera haar vader Fred. Opa Fred zit in een rolstoel maar volgens de website is het museum rolstoeltoegankelijk. Opa Fred wil wel graag mee naar het techniekmuseum, alleen dat verhaal van Vera over PDA's en een virtueel museum volgt hij compleet niet. "Waarom moet techniek tegenwoordig altijd ingewikkeld zijn en al die engelse termen?" het duizelt Opa. Gelukkig heeft Vera hem op het hart gedrukt dat het echt een historisch museum is, zaterdagmorgen komen ze hem ophalen.

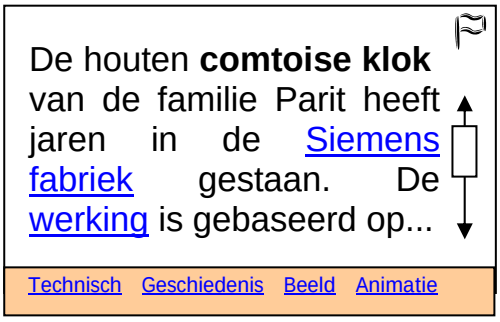
Het bezoek

Bij binnenkomst in het museum wordt hen gevraagd of ze een PDA willen gebruiken. Opa Fred mag kiezen uit een groter scherm, of ook een PDA. Een 'Personal Digital Assistent' oftewel een 'Persoonlijke Digitale Assistent', vertelt de dame achter de receptie. "Doe mij dan maar een assistente" zegt Opa Fred lachend. Het apparaat wordt aan zijn rolstoel geklikt.[1] Ze krijgen een korte uitleg en als ze er niet uitkomen, kunnen ze een knop indrukken en komt iemand (een vrijwilliger of medewerker van het HEIM) ze helpen. Vera had voor het bezoek haar interesses al ingevuld op de website. Ze geeft haar naam op bij de receptie waarna de dame achter de balie deze invoert op de PDA. De PDA is nu voor haar gepersonaliseerd[2]. Ton vindt dat 'personaliseren' niet nodig, hij wil alle informatie krijgen en geen selectie[3]. Eva en Patrick vullen bij de receptie hun interesses nog in op de 2 schermen die op de balie staan.

Opa zet zijn leesbril op, maar moet nog turen voor de lettertjes. Patrick zet de lettergrootte op een iets grotere stand en nu kan Opa het perfect lezen[4]:



Eva vertelt Opa Fred dan hij op alles dat blauw en onderstreept is kan klikken en dat hij echt niks fout kan doen. Het pennetje dat aan de PDA vast zit laat hij zitten waar het zit en hij drukt met zijn vinger op het woord Houten klok. Warempel, het ding doet iets:



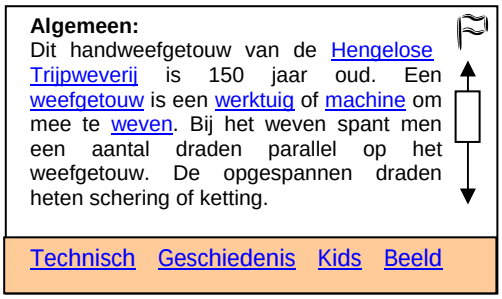
[1] Mogelijkheid bieden voor het gebruiken van meerdere apparaten.
[2] Mogelijkheid bieden om voor het bezoek, de persoonlijke interesses al door te geven.
[3] Personaliseren kan, maar is niet verplicht.
[4] Lettergrootte aanpasbaar.

Ton, Vera, Eva en Opa Fred slaan linksaf, naar het begin van de museumroute. Patrick, eigenwijs als hij is, loopt naar rechts. Eva begint gelijk op knoppen te drukken. Vera bestudeert de PDA om haar onderarm. Ze vond het eigenlijk maar vreemd dat de PDA met klittenband over haar blouse aan haar arm werd bevestigd. Maar het is toch wel lekker dat ze haar handen nu vrij heeft. Helemaal voor Eva die twee handen nodig heeft om zoveel mogelijk knoppen na elkaar in te drukken.[5]

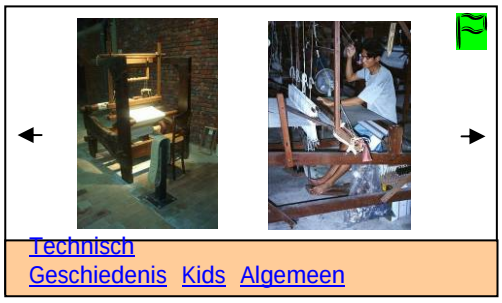
Vera is benieuwd wat ze allemaal met de PDA kan doen. Ze drukt op de groene knop, in beeld verschijnt de tekst:

Het apparaat weet inderdaad waar ze is, voor haar staat een groot handweefgetouw en achter haar een naaimachine, die Eva steeds aan en uit zet.

Vera klikt op handweefgetouw. Nu verschijnt het volgende beeld:



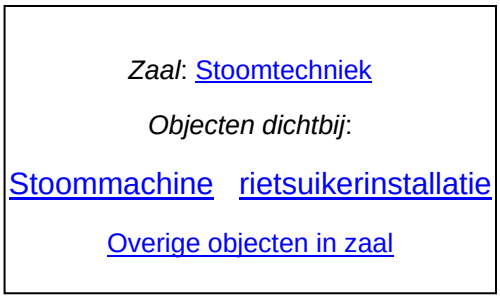
Nadat Vera de algemene informatie gelezen heeft klikt ze op Beeld. Nu ziet ze vooral visuele informatie.



[5] Bezoekers moeten hun handen vrij hebben zodat ze de machines aan kunnen raken.

Vera raakt niet uitgekeken en vindt alles interessant. Ze besluit het 150 jaar oude weefgetouw te bookmarken. Thuis kan ze dan op haar gemak de informatie verder bekijken.[6]

Patrick is rechtsom gelopen en staat voor een grote stoommachine. Nadat hij er omheen gelopen heeft, zet hij zijn PDA aan, om te kijken wat die hem te vertellen heeft.



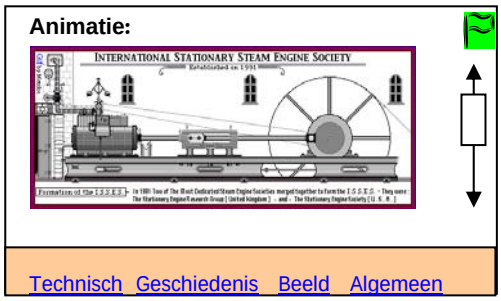
Patrick klikt op Stoommachine.

Omdat Patrick bij de receptie aangegeven had geen Kids informatie te willen hebben is deze optie in zijn scherm niet zichtbaar.

Patrick klikt op Animatie.

[6] Bezoekers moeten de mogelijkheid hebben om objecten te bookmarken en deze thuis via het Internet kunnen raadplegen.

Patrick is nieuwsgierig naar wat er gebeurt als hij op het vlaggetje klikt. Hij heeft gelezen dat deze machine dan 'gebookmarkt' wordt en hij dat dan later op de website van het museum terug kan zien als hij inlogt.[7]



Opa vindt dat er veel te veel informatie in dat scherm zit; hij komt van alles tegen.[8] Ton legt hem uit dat hij op het vlaggetje rechtsboven kan klikken als hij wil dat het systeem onthoudt dat hij die machine interessant vindt. Hij kan dan een keer bij Vera en Ton thuis op de computer alles na lezen. Gelukkig hangen er in het museum nog genoeg doeken met informatie over de objecten die Opa ook kan bekijken.[9]

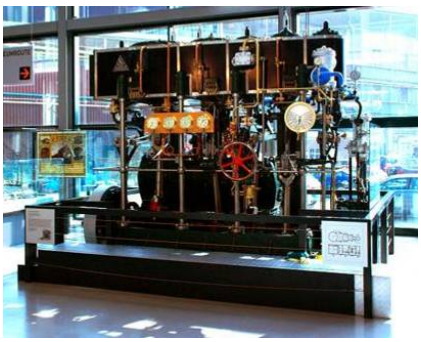
Jan, een vrijwilliger van het museum, laat de Stoommachine draaien, daarna haalt hij met Opa herinneringen op aan het Hengelo van vroeger. Fred vertelt zijn kleinkinderen Patrick en Eva altijd de spannendste verhalen over vroeger. Vrijwilliger Jan vertelt over de verhalensite van Hengelo en van het museum. Opa kan daar al zijn verhalen op kwijt zodat ze bewaard blijven. Opa wil zijn verhalen graag op www.geheugenvanhengelo.nl zetten en besluit Eva te vragen om hem te helpen. Eva kan dan de verhalen typen terwijl ze luistert naar Opa.[10]

[7] Na het bezoek moet men kunnen inloggen op een gedeelte van de website, waarna men toegang krijgt tot de bookmarks.
[8] Bezoekers niet overwelven met informatie, ze laten kiezen tussen een basis of een uitgebreidere versie.
[9] Huidige informatie voorziening niet afschaffen.
[10] Een plek creëren waar mensen hun verhalen kwijt kunnen, deze verhalen kunnen weer gebruikt worden als content voor de PDA.

Website, na bezoek

Als Patrick 's avonds achter zijn computer zit surft hij naar de website van het museum. Hij logt in op zijn eigen, gepersonifieerde gedeelte van de website, mijnHEIM.nl. De website blijft vrijwel hetzelfde, alleen nu ziet hij zijn gelopen route op de plattegronden staan, en af en toe staat er een groene vlag.[11] Patrick klikt op een groene vlag en krijgt dezelfde informatie te zien als in het museum op zijn PDA. Alleen nu is het scherm waarachter hij zit groter en past er dus meer tegelijk in het scherm. Ook zit er meer functionaliteit in, zoals hyperlinks naar andere onderdelen van de website.

Algemeen:



Een **stoommachine** is een soort motor (of, in bredere zin een soort machine) die de energie van hete, onder druk staande stoom voor een deel omzet in mechanische arbeid. In het algemeen gebeurt dat door de stoom in een of meer zuigers te laten expanderen en de expansiearbeid op een vliegwiel over te brengen.

De uitvinding van de (industriële) stoommachine markeerde het begin van de industriële revolutie; voor het eerst was arbeidsvermogen overal realiseerbaar om machines aan te drijven, waar voor die tijd met handkracht, trekdieren, watermolens en windmolens moest worden gewerkt. De stoomlocomotief is een bekende toepassing van de stoommachine. Voor tijdelijk of licht werk kon een *locomobiel* worden ingezet.

Zuigerstoommachines worden tegenwoordig eigenlijk niet meer gebruikt. Waar behoefte is aan een onafhankelijke krachtbron is een stoomturbine, dieselmotor, benzinemotor of aggregaat vrijwel altijd efficiënter, goedkoper, minder vervuilend en/of lichter.

Technisch Geschiedenis Beeld Animatie Kids Getallen

[11] Duidelijk maken dat de website en de PDA bij elkaar horen, dingen laten terugkomen.

E-mail van Techniekmuseum HEIM

Vera heeft een e-mail ontvangen van Techniekmuseum HEIM. Vier maanden geleden gaf ze aan onder andere geïnteresseerd te zijn in historische fotografie en op de hoogte gehouden te willen worden van nieuwe tentoonstellingen. In de e-mail staat dat vanaf volgende week de nieuwe fototentoonstelling over Tuindorp van start gaat.[12] Zaterdagmiddag tijdens Eva's twaalfde verjaardag vraagt Vera of vriendin Tessa mee wil naar deze tentoonstelling. 's Avonds stuurt ze de e-mail van het museum door aan Tessa.

Twee weken later gaan de twee vrouwen op zondagmorgen naar het museum. Na de tentoonstelling volgen ze een fietsroute door Tuindorp en dineren ze in de stad.[13] "Wat een leuk dagje zo," zegt Tessa "zoiets moeten we vaker doen."

[12] Bezoekers aan het museum binden door gerichte uitnodigingen te versturen aan de hand van de opgegeven interesses.
[13] Combinatie activiteiten aanbieden.

D.2 **Scenario 2: Cornelis (33), conservator van Techniekmuseum HEIM**

Cornelis heeft zorgvuldig het hele museum ingedeeld. Welke objecten moeten in het museum komen, en waar moeten ze dan staan? Naast zijn eigen mening tellen ook de meningen van de vrijwilligers en medewerkers van het museum mee. Met de huidige opstelling is iedereen wel tevreden, al zijn er natuurlijk altijd discussies. Is de draaibank wel interessant genoeg, en staat dat noodaggregaat daar wel goed? In het depot staan ook nog 30.000 stukken waarvan vele een plaatsje in het museum verdienen.

Sinds kort beschikt het museum over een systeem voor plaatsbepaling. Dit heeft niet alleen voordelen voor de bezoeker, die gerichte informatie krijgt aangereikt, maar ook voor het museum. Cornelis kan op zijn computer zien hoe vaak een bepaald object gebookmarkt is en hoe groot de bezoekersstromen zijn die door de gangen en zalen lopen.

Het blijkt dat het doodlopende gangetje waar het noodaggregaat staat, slechts door 20% van de bezoekers die er langs komen ook bekeken wordt. Tijdens de volgende vergadering wordt overlegd of hier iets aangedaan moet worden. Misschien moet er iets bijkomen dat de aandacht trekt, waardoor het aggregaat anders gepresenteerd wordt. Of misschien moet hij wel verplaatst worden. Van de 20% die het aggregaat bekijken bookmarkt een flink aantal mensen het object, oninteressant voor de bezoekers zal het aggregaat dus niet zijn.

Bij de draaibank blijkt bijna niemand stil te staan; hij wordt zelfs nooit gebookmarkt. Cornelis wil een voorstel doen om dit object naar het depot te brengen en er een ander object voor in de plaats te zetten.[14]

[14] De museumapplicatie moet inzicht geven in de bezoekersstromen. Laten zien hoe vaak een object bekeken wordt en gebookmarkt.

D.3 Boekjes scenario

Meneer en mevrouw Hogekamp, 62 en 63 jaar.

Meneer en mevrouw Hogekamp wonen net iets buiten Hengelo in een mooie oude boerderij. Op zondagmorgen besluiten ze de fiets te pakken en naar de stad te fietsen. Nadat ze een aantal boodschappen hebben gedaan fietsen ze terug naar huis. Onderweg komen ze langs de Wilhelminaschool, hierin is Techniekmuseum het HEIM gevestigd.

Jaap: *Ria, moet je kijken wat een boel fietsen bij de oude Whilhelminaschool, zou daar iets te doen zijn?*

Ria: *Ik heb gehoord dat daar tegenwoordig het techniekmuseum in zit.*

Jaap: *Lijkt het je wat om even naar binnen te gaan?*

Ria: *Ja laten we dat doen, de was hangt wel buiten maar het ziet er naar uit dat het droog blijft.*

Balie: *Goedemorgen, 2 kaartjes?*

Jaap: *Ja graag.*

Balie: *Zijn jullie toevallig bekend met computers? Onze kaartjes zijn tegenwoordig namelijk iets groter, er zit een gids in die je van alles kan laten zien, horen en beleven over de tentoonstelling.*

Jaap: *Uh pardon, dat gaat me iets te snel, wat is er aan de hand?*

Ria: *Je bedoelt een gidsje met informatie over de tentoonstelling, waarin je dan dingen op kunt zoeken?*

Balie: *Het is inderdaad een gidsje waarin je dingen op kunt zoeken over de tentoonstelling, het is een digitaal apparaatje. Niet van papier dus. Ik zal er even eentje voor jullie pakken.*

Jaap heeft inmiddels zijn oog laten vallen op het scherm aan de wand. Deze presenteert de Informatie Assistent die je als bezoeker van dit museum mee krijgt. Het is een soort tekenfilm en het ziet er nog vrij eenvoudig uit, vindt Jaap.[15]

Jaap: *Had je je leesbril nou bij je?*

Ria: *O, nee. Nou dan lees jij de bordjes toch gewoon even voor als ze interessant zijn?*

Balie: *Willen jullie allebei een gids, of eentje voor jullie samen? Ze zijn gratis hoor.*[16]

Ria: *Eentje is wel goed hoor, we doen wel samen.*

Dat is toch wel grappig, nieuwe techniek gebruiken om de oude te laten herleven, denkt Ria. Alleen snap ik die oude technieken ook niet allemaal, dus hoe zal het gaan met dat apparaatje? Ik hoop dat Jaap het een beetje snapt, anders doen we het maar zonder.

Balie: *Ik heb voor beide een oortje, die hang je gewoon om je oor, ja zo inderdaad. Daardoor hoor je het geluid van de gids. Je kunt het volume zelf regelen, dat wijst zich zometeen vanzelf.*

Jaap: *En nu kunnen we daar ons emailadres invullen enzo?*

---

[15] Bezoekers moeten gelijk bij binnenkomst al in aanraking komen met de gids. Wanneer ze een gids wordt aangereikt moeten ze eigenlijk al weten wat het is.
[16] Mensen zijn waarschijnlijk eerder geneigd de PDA te proberen als hier geen extra kosten aan verbonden zijn.

Balie: *Ja inderdaad, dat wilde ik net vertellen.*

Jaap: *Ik had het op het filmpje al gezien, vandaar.*

Jaap pakt het apparaat op en loopt ermee naar het aanmeldstation. Hij legt het apparaat nu op de blauw verlichte plaat. Er schuift een toetsenbord naar buiten en het scherm vraagt om een naam.

Ria: *Vul maar Hogekamp in, Jaap.*

Daarna kunnen ze een aantal dingen kiezen: of ze jonger dan 12 zijn of 12 jaar of ouder zijn. Willen ze een basisgids of een uitgebreide gids, daarnaast kunnen ze klikken op de onderwerpen die ze interessant vinden. Ze kiezen voor techniek en geschiedenis van Hengelo.

Nu kunnen ze een assistent kiezen.

Ria: *Kijk Jaap, dat lijk jij wel die professor met dat brilletje, zullen we die doen?*

De professor begroet 'Hogekamp' en geeft een introductie over de werking van de gids. Als ze interesse hebben wil de professor ze meer vertellen over de werking van het systeem. Jaap en Ria besluiten later de werking van het systeem te bekijken, ze willen nu het museum wel eens in, samen met de professor.[17]

Jaap kijkt op het scherm van het apparaatje en ziet de interface die de professor net uitgelegd heeft. De professor zelf staat in het midden op een kaart. Precies waar zij nu ook staan. Als ze de eerste zaal inlopen verschijnen de eerste objecten in beeld. Jaap klikt op een tekening van een naaimachine. Er verschijnt een kaft van een boek in beeld met daarop de naam van het object, een foto en een aantal icoontjes. Jaap ziet daaraan dat er een Quiz is over dit object en algemene informatie.[18] Jaap opent het boekje en de professor begint te vertellen. Op het aanmeldstation hadden ze aangegeven audio te willen, omdat Ria haar bril niet mee heeft.

Ria was al twee meter doorgelopen en hoort nu de professor praten.[19] Ze draait zich om richting Jaap, die geïnteresseerd naar een naaimachine kijkt, dat komt niet vaak voor. Ria gaat aan de andere kant staan. De professor zegt dat ze de naaimachine aan kunnen zetten door op de knop aan de zijkant van de kast te drukken.[20] Jaap doet dit, Ria is verbaasd: "Waarom is een naaimachine nu opeens interessant? Als ik er thuis mee aan het werk ben komt hij nooit kijken."

De professor is uitgepraat er klinkt een piepje. Net als die luisterboeken die ze vroeger voor de kinderen hadden. Bij het piepje moest er dan een bladzijde omgeslagen worden. Jaap klikt op de 'omslaan-knop' en de professor praat verder. Na het volgende piepje slaat Jaap weer om. Nu komt er een Quiz. Ria staat inmiddels bij een ander object maar hoort de professor nog steeds via haar oortje. "Volgens mij is het B", zegt ze. Jaap is eigenwijs en kiest voor A, dat is fout natuurlijk. Gelukkig kunnen ze er om lachen!

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[17] De opstartfase moet niet te lang duren. Sommige zullen veel aan willen passen aan hun eigen wensen, andere willen het liefst zo snel mogelijk aan de slag. Dit moet beide kunnen.
[18] Aangeven wat de bezoeker kan verwachten aan informatie over een object.
[19] Door het gebruik van audio hoeven de twee gebruikers niet continu naast elkaar te blijven lopen.
[20] De content moet de gebruikers wijzen op het object, om ervoor te zorgen dat er interactie plaats vindt tussen de bezoekers en het object, en niet alleen tussen de PDA en de bezoekers.

Appendix E: Button size calculations

To calculate the minimum button size the anthropometric dataset 'Dutch adults', Population 'DINED 2004 (20-60 years)' from the Delft University of Technology was used. [38] I find it acceptable that touching the buttons will be a little bit harder for 5 percent of the adults, so that the buttons don't have to become a lot bigger to satisfy just a small amount of users. That is why calculations were based on the P95 forefinger and the P95 thumb breadth of the adult population. The DINED dataset gives me the date for males and females, to translate those values to the whole adult population I presume that 50 percent of the users will be male and 50 percent will be female.

Data from DINED:

	male MEAN	male SD	female MEAN	female SD
thumb breadth	24	2	21	2
forefinger breadth	18	2	16	2

With the following formulas from DINBelg [52] the average value (MEAN), the standard deviation (SD) and the value that corresponds to the 95ste percentile (P 95) for the adult population were calculated.

Formulas:

$$\mathbf{mean_{A+B} = \%A * mean_A + \%B * mean_B}$$

$$\mathbf{SD^2_{A+B} = \%A * SD^2_A + \%B * SD^2_B + \%A * \%B * (mean_A - mean_B)^2}$$

$$\mathbf{P\ 95 = mean + 1{,}65 * SD}$$

	adults MEAN	adults SD	P 95
thumb breadth	22,5	2,5	26,6
forefinger breadth	17	2,24	20,7

The fingerprint area, the part of the forefinger breadth that is used for activating a touchscreen button, is not a measurement in the DINED dataset. To get an indication of the fingerprint area I conducted a little test. For this test the fingerprint of one male and one female were measured (multiple times), and compared with their forefinger breadth. The same was done for the thumb. The indication that was gotten from this test is that the finger or thumb print area is approximately 65 percent of the breadth. That means that the P95 forefinger-print and de P95 thumb-print are 65% of P95 forefinger breadth and P95 thumb breadth.

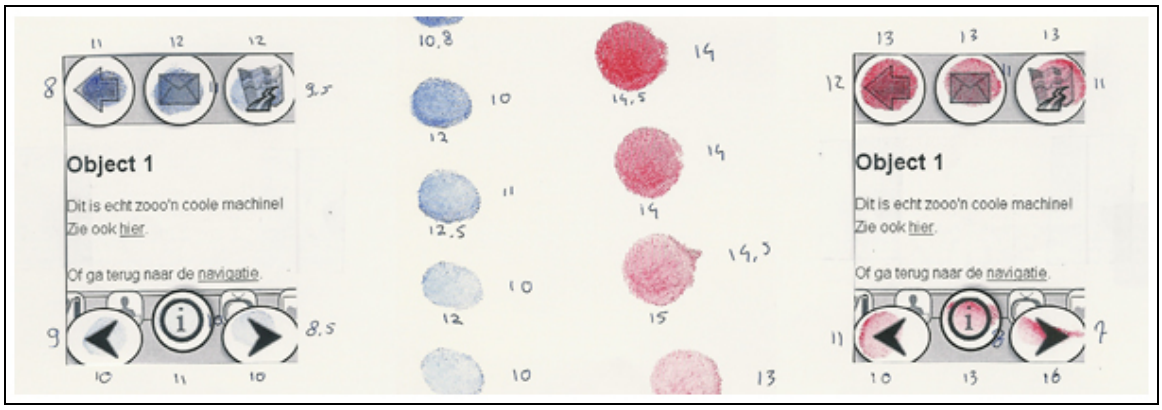


Figure above shows:a sample of the fingerprint and thumbprint test.

In the table below the amount of buttons that fit in the width and height of the two sizes of PDA screens that were used during testing, are listed.

	Ø 3,5 inch		Ø 2,8 inch	
	w: 53,3 mm	h: 71,1 mm	w: 42,7 mm	h: 56,9 mm
P95 forefinger breadth – touch: 13,45 mm	3,96	5,28	3,17	4,23
P95 thumb breadth – touch: 17,29 mm	3,08	4,11	2,47	3,29

Looking at the table above, a maximum of 3 buttons horizontally and 4 buttons vertically is appropriate for both screens when using the forefinger as input device. Using the thumb on the 3,5 inch screen is also expected to be without problems, but on the 2,8 inch screen this might get tough. On the other hand, when people use there forefinger as input device on the 3,5 inch screen, 4 buttons width and 5 buttons height could also be possible. To be able to make a good decision it is important to know which part of the adult population will still be able to easily manipulate the touchscreen buttons.

	3 buttons horizontal	4 buttons horizontal	4 buttons vertical	5 buttons vertical
Ø 3,5 inch	17,77 mm	13,33 mm	17,78 mm	14,22 mm
Ø 2,8 inch	14,23 mm	10,67 mm	14,23 mm	11,38 mm

With the formula 'Z = (X – gem.) / SD' the percentage of the adult population that will be able to easily activate the buttons was calculated.

	Ø 3,5 inch	Ø 2,8 inch
	3 horizontal buttons	
$P_{\text{forefinger breadth}}$:	99,9 %	98,6 %
$P_{\text{thumb breadth}}$:	97,3 %	40,5 %
	4 horizontal buttons	
$P_{\text{forefinger breadth}}$:	94,1 %	39,7 %
$P_{\text{thumb breadth}}$:	21,2 %	0,8 %
	4 vertical buttons	
$P_{\text{forefinger breadth}}$:	99,9 %	98,5 %
$P_{\text{thumb breadth}}$:	97,4 %	40,1 %
	5 vertical buttons	
$P_{\text{forefinger breadth}}$:	98,5 %	59,1 %
$P_{\text{thumb breadth}}$:	40,1 %	11,5 %

To assure that 95 percent of the adult users will be able to touch the buttons on the screen easily, at most 3 buttons horizontally or 4 buttons vertically will be used during the user tests. Users who will use their thumb as input device can have some trouble on the 2,8 inch screen. This can be easily solved by using the forefinger instead of the thumb.

There are some other factors that influence the minimal button size on a touchscreen. For example: the difficulty of placing the finger on a small button when the finger itself is blocking the view and the fact that the touchscreen button is not tangible like on a TV-remote control. But on the other hand, the part of the finger that hits a touchscreen button first is smaller that the 65% of the forefinger breadth. Still testing is needed to be sure that the buttons have the right size.

Appendix F: Bookmark survey, statics and analysis

Enquête

Zometeen wordt je gevraagd een icoon te kiezen voor een knop op een apparaatje die ik tijdens mijn afstuderen aan het ontwikkelen ben. Omdat de actie die met de knop uitgevoerd wordt relatief nieuw is, is het lastig om een afbeelding te vinden die met deze actie geassocieerd wordt. Hier heb ik jou hulp dus voor nodig.

Hier volgt nu eerst een korte introductie:

Daar sta je dan, voor de ingang van Twents techniekmuseum het HEIM.

Binnen bij de balie krijg je een 'Persoonlijke Informatie Assistent' uitgereikt. Dit is een apparaatje zo groot als je hand.

Met dit apparaatje kun je de, speciaal voor jou geselecteerde, bestanden van een object bekijken. Je kunt bijvoorbeeld luisteren naar een verhaal, een film bekijken of uitleg krijgen over de werking van een machine in het museum.

Je staat nu tussen een aantal machines in het museum.

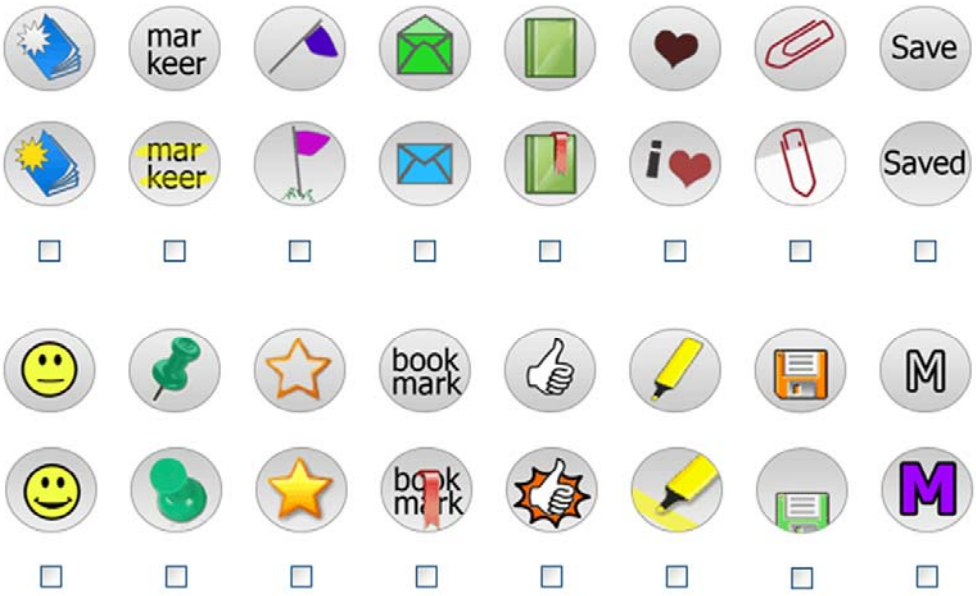
Op de 'Persoonlijke Informatie Assistent' zie je je eigen positie binnen het museum op een kaartje. Ook de machines waar je tussen in staat, staan op de kaart. Je klikt een machine op het scherm aan. Nu treedt je de informatie wereld van deze machine binnen en kun je van alles bekijken en beluisteren.

Van het object waar je nu voorstaat, de "Triple expansie stoommachine", ben je zo onder de indruk dat je de bijbehorende informatie thuis nog even rustig wilt bekijken. Om te zorgen dat je assistent dit onthoudt druk je op de knop met het vraagteken. Welk icoon zou volgens jou op de plek van het vraagteken moeten komen te staan?

Hieronder staan 16 iconen die op de plaats van het vraagteken kunnen staan. Het bovenste icoontje is degene waar je op klikt, nadat de assistent jouw actie heeft onthouden verandert het icoontje in het onderste plaatje.

Jouw keuze

Welk icoon verwacht jij op de plaats van het vraagteken?
(Je mag meerdere iconen aanvinken)



Waarom heb je voor dit icoon (deze iconen) gekozen, wat is je reden?

Over jou

Naam:

Leeftijd:

Computer Ervaring

Hoeveel tijd breng je wekelijks door achter de computer?

- Ik gebruik geen computer
- 1-5 uur per week
- 5-10 uur per week
- 10-20 uur per week
- 20-40 uur per week
- Meer dan 40 uur per week

In hoeverre ben je bekend met het gebruik van een PDA (persoonlijke digitale assistent)?

- Ik bezit een PDA en gebruik hem regelmatig.
- Ik heb een PDA maar gebruik hem niet meer.
- Ik heb weleens de PDA van iemand anders gebruikt.
- Ik ben niet bekend met het gebruik van een PDA.

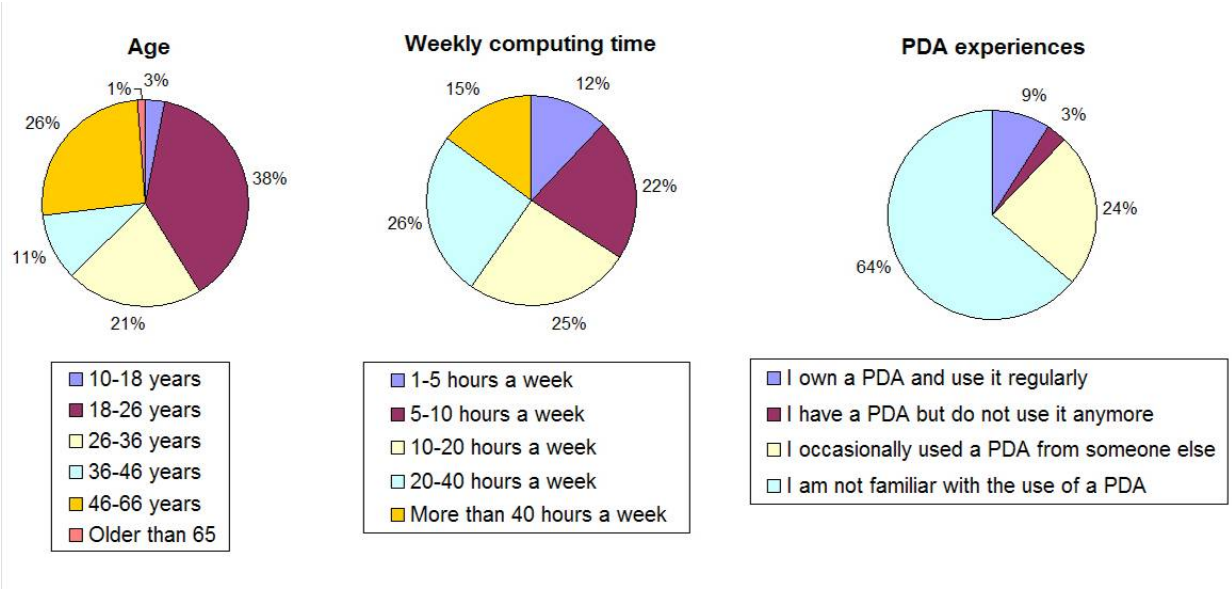
Versturen

Bedankt voor het invullen en vergeet niet hierboven op 'Versturen' te klikken!

Marieke Steltenpool

The statistic results from the bookmark survey and the bookmark survey analysis.

188 people participated in the survey, with ages ranging from 10 to 78 and an average age of 35. Together they marked a total of 303 icons. The spread in age of the bookmark survey participants and their weekly computing time and if they have experiences with PDAs is visualized in the figure below

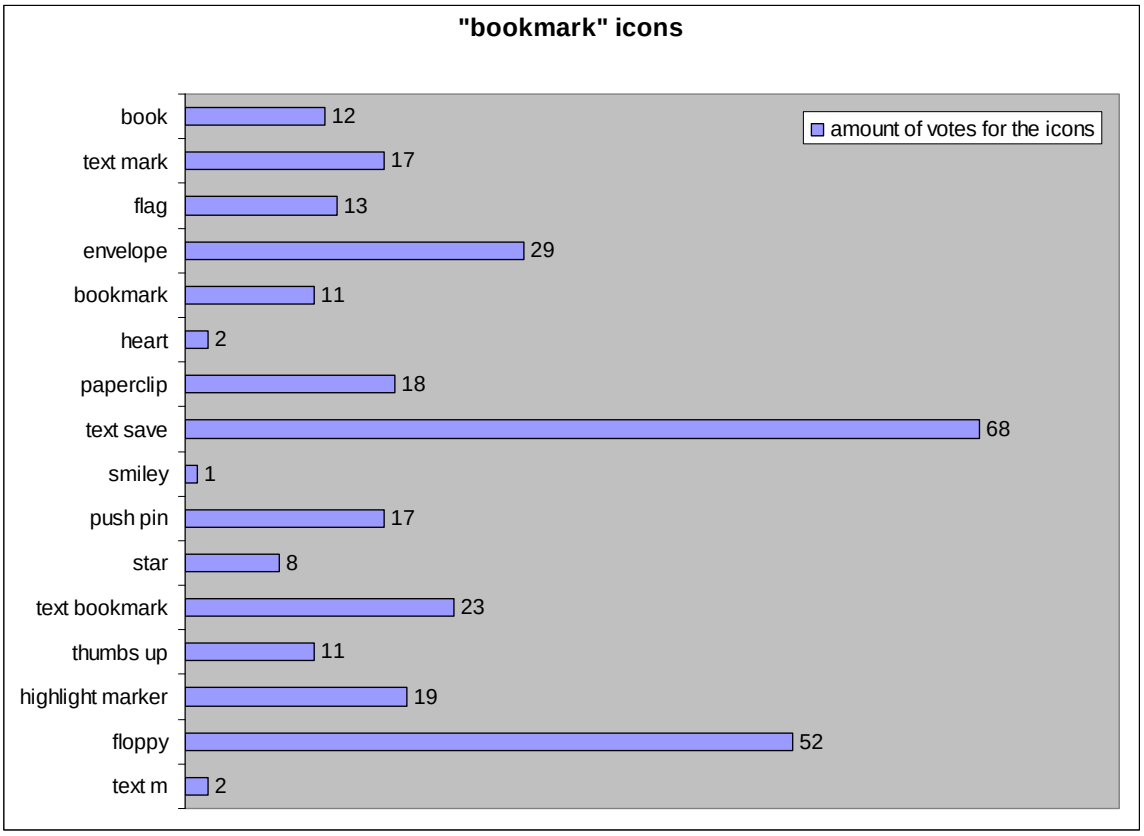


Results

The statistic results from the bookmark survey participants' choices are shown in figure below. Besides the statistic rating of the icons the given reasons for choosing these symbols are very important. Why did they choose these icons, what do they think the bookmark button does?

The first of the 16 icons is the original icon from the designed interface used in the scenario of the bookmark survey, designed by Egon van Engelen at SIS. People might have chosen for that icon just because it fits in the visual style of picture. But when analyzing the reasons of the 12 persons who choose that icon, only one gave as reason that it matches to the rest of the icons in the interface.

The text 'save' is selected most according to the data of the bookmark survey. Almost half of the people that choose the text 'save' gave the explanation that they want to save the information, and almost 40 percent of the people find the term clear and unambiguous. Almost 80 percent of the people that choose 'floppy' as icon mentioned they want to save the information, 23 percent mentioned the familiarity of the floppy. 19 percent mentioned that the floppy icon makes clear that the information can be read again later. The envelope icon ended third, but cannot be easily used for the bookmark purpose because this metaphor is already used for the messages that the museum will send to the visitor. The reason for including this icon in the bookmark survey is because e-mail is mentioned as the right metaphor by Filippini-Fantoni and Bowen [23]. From the 29 persons that choose the envelope as replacement of the question mark 40 percent gave as a reason that the information has to be send or mailed home and 21 percent gave as reason 'to save the information'.



Far from all of the people that took part in the bookmark survey provided an explicit reason that gives an insight into their mental model with regard to the 'bookmark' button: 31 percent did not provide an explanation. 36 percent of the 188 persons mentioned that what the button has to do is 'save the information for them', 9 percent that the information has to be remembered and 6 percent that the information has to be send. The term bookmark is mentioned by only 7 percent of the persons. Saving is the winning metaphor from this survey.

60 percent of the visitors of TTH are schoolchildren, but the amount of children that filled in the bookmark survey is low. Therefore special attention has been given to the answers of the youngest persons that filled in the survey and a schoolteacher. Dirk Joosse, 10 years old, choose the floppy as 'bookmark' icon. This is despite the fact that we would not even expect him to know what a floppy is. But Dirks reason is (translated form Dutch) that "in a diskette you can generally save things that you can store. This is clear to everyone, and everyone can understand it." Vincent Blokker, 24 years old is a schoolteacher for 10-11 year olds. His reason to choose the floppy icon is that the thing you want to do is remembering something and therefore save it. He also mentioned that children will recognize this icon from other computer programs, like Microsoft Office Word; they will already know what it is for. So the metaphor for saving, in fact, is still a floppy disk although a floppy itself is hardly used anymore. The floppy disk might be the archetype for saving, like a telephone horn is for calling and a magnify glass for zooming in-out and searching. Nowadays children grow up with software and learn that a picture of a 3,5" disk means save. If we would update that icon, to a USB stick for example, we have to

continue updating the icon every time technology changes. Using words might be an option; we could just use the word Save (English) or Opslaan (Dutch).

The 'bookmark' icon

Several persons used the text area 'your reason for choosing this icon' to recommend other icons. Metaphors and icons that were recommended are:

- A floppy disk that receives a checkmark when active.
- A little house.
- The 'i' from information that flies towards a little house.
- A heart with a question mark that turn is 'I love' when active.
- A shopping cart/ basket.
- A USB stick.
- The text 'opslaan' (save in Dutch).
- Bewaar/bewaard (save/saved translated into Dutch).
- The text 'Mail me'.
- The floppy icons reversed, first half than whole.
- An expanding floppy disk.
- An open envelope with a little arrow, to show that something can be put in the envelope.
- An icon that will make a sound like "ping" or that glows when you activate it.

Appendix G: Research on audio and text

G.3 Audio

Museum visitors remember more from an audioguide than from reading the labels [17]. Audio also benefits people with visual and/or reading impediments like reduced visibility or dyslexia. Furthermore, a number of people prefer to listen instead of read, as was observed during user tests. Another important advantage of making use of audio is that when users listen to audio they can simultaneously investigate the museum object, whereas they would look at the screen when they read text.

Speech

The vocabulary used for text and audio needs to be familiar to all users [31] or different versions of audio and text files should be made for the different user groups. For example a version for children up to 12 could be made with a suitable vocabulary for this group.

Frequencies above 4000 Hertz need to be avoided because elder people get problems with hearing sounds above that frequency [31, 53]. Therefore a male voice will be a good choice for the audio, because the voices of women and children are mostly higher pitched and therefore less hearable for some people. The speech rate of radio and TV newscast announcers is a good speed to employ for the spoken text [31].

Sound

Which volume level is comfortable differs per person. Hearing disabilities and ambient noise are of big influence on the volume level. The ambient sound is a variable factor, so the user has to be in control of the audio volume. Instructions on how to control this volume have to be given when introducing PIA to the user. The volume to the ear may not exceed 80 dB. Above that level it can damage the ear when exposed to the sound for more than 8 hours [54].

Ambient sound can interrupt in the spoken text, distributed to the user through the speaker of the PDA or an earpiece. Even with an earpiece the ambient sound in the TTH can be loud enough to make it difficult for the user to understand the audio. This problem can be solved by giving the user two earpieces, which better insulate the user from the ambient sound [31]. Although that might influence the social experience of a museum visit negatively. The solution for PIA in TTH is to give the user two earpieces connected to the PDA. The user can use one earpiece and is able to use the second one when the ambient noise is becoming too loud. Due to working machines as museum objects and a building that reflects a lot of sound, the TTH suffers from a lot of ambient noise that can not be easily reduced. People who still have a problem listening to the audio with two earpieces can choose to use the visual channel by reading the text instead of listening to it.

Recording

On PIA, instead of reading the texts one can also listen to the text, spoken by a male voice (Bas Löverink). The introduction movie on PIA is accompanied by a female voice. The audio recording for PIA is done with a laptop, a microphone and the digital audio editor GoldWave Inc [55]. The male voice was recorded by using a capacitor microphone, whereas the female voice was recorded with a budget headset. When comparing the two, the recordings made with the headset contained much more ambient noise. But with the GoldWave software this was filtered out. The quality of the recorded sound files, after noise reduction, was comparable and qualified as good by the users during the demo in TTH. So in addition to expensive hardware and a studio, appropriate software can also be very helpful. It should be tested if it is possible to obtain audio of good quality with a microphone and the GoldWave software when recording the stories volunteers tell during tours. The quality of the spoken text can be improved when it is recorded in a studio with professional voices, but that also means it is more complicated to change an audio file. For example, in the Van Gogh museum and NAI the first audio streams are spoken by the previous managing director and it is too much effort to record the files again. With PIA, museums can maintain the content themselves; it would be awkward if that does not go for the audio. A mix could work best, using sound files recorded in a studio that can be updated with a microphone and a digital audio editor.

This results in three guidelines for using audio on a device like PIA.

Guidelines for audio:

Speech rate: The speech rate of radio and TV newscast announcers is a good speed to employ for the spoken text.

Voice: Frequencies above 4000 Hz need to be avoided; therefore male voices are a better choice.

Sound volume: The user has to be in control of the volume.

G.2 Text

In addition to audio and movies, the interface also contains text. Text is used for general information, operation information, information about the inventor, quizzes and messages. General information, operational information and inventor information are also presented as audio. For the design of a PDA user interface it is important to know how text it is best presented to the user, including the optimal size, typeface and color for the text

Font (size)

On PIA, a 12-point font size was used. This text size was shown to some older volunteers of TTH. The volunteers complained the text was too small for them to read comfortably. To accommodate for users with reduced sight, a large font size version was added with a font size of 14 points. Enlarging the text is of influence on the presentation of the summary texts of all objects, because more space is needed. These texts are rewritten in order to reduce the length. According to the guidelines for text presentation in the book 'Designing for older adults' a 12-point font size is appropriate for older users, but this statement ignores the density of pixels(known as "dots per inch", or dpi) of the screen the text is presented on [31]. The dpi of the screen is of great influence on the perception of the presented text, which might be the reason why a 12 point font size on the 320x240 PDA screen is too small for people with reduced sight.

Font type

The legibility of serif fonts is better than sans-serif fonts [53], but details of the serif fonts may be lost on the low resolution of the PDA screens in comparison to paper [30]. Which font type can be used depends on the fonts that are available on the PDA's. Therefore a font declaration is used with a first (Arial), second (Helvetica Neue), third (Helvetica) and fourth (any sans-serif font) choice. If the font specified by the first choice is not present, the second is taken, and so on. Titles are set in upper-case text because they attract more attention when the rest of the text is in lower case [31].

Font color

Environmental lighting and the reflection of shining objects reduce the amount of contrast between elements on the screen. To compensate for this effect, the difference in luminance between fore- and background (the contrast) has to be higher. The luminance of light colors on the PDA display is far less influenced by environmental light than the dark colors. According to den Buurman the contrast ratio on active displays for light characters on a dark background should be between 7:1 and 12:1. With dark character on a light background a contrast of 1:3 can be sufficient, because the environmental lighting has a relatively light influence on the light parts of the screen. Also the hindrance of glare due to reflection on the screen is much smaller when dark characters and a light background are used [40]. For the best legibility of text at reading distance black characters are used on a white background [53].

Scrolling text

An advantage of the ability to scroll text is that it makes the text screen-size independent. That means that the content-creator is not bound to a maximum amount of characters in one item of text. But some people, especially older adults, can have difficulties with scrolling text [31]. Paging instead of

vertical scrolling might be a better solution; at least scrolling fluently is preferred above jumping per line [40].

This results in four guidelines for text on PDA screens.

Guidelines for text on active displays:

Font size: For a 240x320 PDA screen, let users choose between a 12 point font size version and an enlarged version with a14 point font size.

Font type: Prefer sans serif fonts, such as Arial or Helvetica. Upper-case text can be used for titles to attract attention.

Font color: Use dark characters on a light background with at least a contrast ratio of 1:3.

Text length: When using vertical scrolling it is preferred to scroll fluently instead of jumping per line. Another solution for longer sections of text is paging.

References for Audio and Text

1. Hornecker, E. and P. Bartie, *Techonology in Tourism: Handheld Guide Systems and Museum Technologies*. 2006, Human Interface Technology Laboratory New Zealand.
2. Fisk, A., *Designing for older adults: principles and creative human factors approaches.* 2004: CRC Press. 158.
3. KITTZ, *Documentatie Ouderen en Technologie*, in *Design for All*. 2001.
4. van der Laan, R., *Arbojaarboek 2004*. 2004: Kluwer.
5. *GoldWave Inc*. 2008 [cited; Available from: http://www.goldwave.com/.
6. Stone, D., et al., *User Interface Design and Evaluation*. 2005: Elsevier, Morgan Kaufmann.
7. den Buurman, p.d.I.R., *dictaat ontwerpen ergonomie* 1996.

Appendix H: Guidelines

General interface guidelines

The general guidelines used when designing the Virtual Museum. The guidelines are divided in (1) handheld device guidelines, (2) interface guidelines for the elderly and (3) icon design together with criteria for effective symbols.

Handheld device guidelines

Gong and Tarasewich [29] transformed typical desktop guidelines for mobile handheld interfaces from which the following guidelines are adapted to be used when designing the user interface:

Offer informative feedback.

- For every operator action, there should be some system feedback, such as a beep when pressing a key or an error message for an invalid input value.

Design dialogs to yield closure.

- Users should be given the satisfaction of accomplishment and completion.

Support internal locus of control.

- Users want to be in charge of the system and have the system respond to their actions, rather than feeling that the system is controlling them.
- Systems should be designed such that users initiate actions rather respond to them.

Consistency.

- The "look and feel" should be the same across multiple platforms and devices.
- Elements of mobile interfaces such as names, color schemes, and dialog appearances should be the same as their desktop counterpart.

Design for multiple and dynamic contexts.

- Allow users to configure output to their needs and preferences (e.g., text size, brightness).
- Allow for single- or no-handed operation.
- Have the application adapt itself automatically to the user's current environment.

Design for small devices.

- Provide word selection instead of requiring text input.

Design for limited and split attention.

- Provide sound and tactile output options.

Design for speed and recovery.

- Allow applications to be stopped, started, and resumed with little or no effort.

– Application should be up and running quickly.

Design for "top-down" interaction.

– Present high levels of information and let users decide whether or not to retrieve details.

Allow for personalization.

– Provide users the ability to change settings to their needs or liking.

Design for enjoyment.

– Applications should be visually pleasing and fun as well as usable.

This list can be extended with the following two guidelines adapted from the book 'User interface design and evaluation [30]' and also specifically aimed at handheld devices:

Clickable graphics should look clickable.

– If a graphic is clickable, then it should have defined borders and the graphic should have high contrast with the background color. Conversely, graphics that are static should not appear to be clickable.

Use icons to clarify concepts.

– Icons should be meaningful and representative of the concepts they are meant to convey.

Interface guidelines for the elderly

The following list of guidelines is a summarization of the guidelines in the book 'Designing for older adults' that are useful when designing a multimedia guide:

Minimizing steps and buttons

– Minimize both the number of steps in the procedure (e.g., button selections and presses) and the number of controls (e.g., buttons).

Physical characteristics

– Allow adaptability (increase font size)
– Ensure that screen characters and targets are conspicuous and accessible (e.g., font size less than 12 point should be avoided); icons should be large enough to select easily; auditory information should be presented at the proper pitch, frequency, and rate.

Navigation

– Provide search history: users need to know which pages have already been visited (e.g., in a list of items, change the color of pages previously visited).
– Provide navigation assistance (e.g., how to link back to particular points in the system, not just going back to the home page but back to a previously relevant page).

Information organization

- Optimize information organization within natural or consistent groupings (e.g., group information that is related); keep most frequent operations highest in the menu structure.
- Frequent and important actions should be easily visible and accessible (how to check out, how to exit from a system, how to save a file).

Icon design

According to ISO 2461-1 described in the book 'User Interface voor Apparaten' from ir. T.A. ter Hark. The following points have to be taken into account when designing icons:

- Start with a clear description of what the icon has to express, where and in which context it will be used.
- Find similar expressing icons.
- Design an icon and show it to as much people as possible while asking them what they think it means.
- Formulate a meaningful caption for the designed icon.
- Keep the icon simple. Don't use too many and too thin lines.
- Design icons in a 75x75 mm area and reduce them later.
- Be aware of the fact that the icons can be interpreted differentially if they are turned around 90 or 180 degrees.
- The height of an icon can be calculated by itemize the viewing distance through 100.

Effective symbols

Criteria for effective symbols adapted from Cushman and Rosenberg 1991, Stone et al 2005 and Raskin 2000 [30, 33, 34]:

- A symbol should be pleasing and noncontroversial, and it should be suitable for a variety of cultures and situations.
- Newly developed symbols should not conflict with existing national or international standards.
- *Symbols should be easily distinguished from each other.*
- *Symbols should be easily recognized and understood.* The users must be familiar with the illustrated object and be able to associate it with the underlying concept.
- *Symbols should be visually simple.* An icon should not contain unnecessary detail. For example, a printer icon does not need to include all the buttons and trays.
- *Symbols should be informative.* For example, the left- and right- justify icons used in some word processors illustrate how the text will look.
- *Symbols should represent concrete objects.* A symbol and its message should be easily associated.
- *Symbols should be easy to perceive*. It is important to choose colors carefully and to avoid too much complexity, or the icon could be difficult to perceive.
- To let the symbols be most effective, no more then 12 of them should be used in the interface and no more then 12 must be shown at one page.

Multimedia guide and content guidelines

Guidelines for the multimedia guide and content, distilled from visitor experiences.

The following lists with aspects that enables multimedia guides to enhance the experience, has been distilled of the visitor experiences in the Market Research and was mentioned in section 5.1: How to enhance the visit.

A **multimedia guide** should:

- allow users to choose the information they access;
- support social interaction among visitors;
- support talking and discussing among visitors;
- have an interface designed according to general interface guidelines;
- tell the user what to expect, so users can experience the tour is a coherent way;
- react quickly (within one second) to user commands;
- give the user the feeling that it adds something to the museum experience.

The **content** should:

- add information, and not just present it in a different way;
- provide the user with information he finds interesting;
- provide texts which users find satisfying;
- contain audio fragment users find nice to listen to.

And a **multimedia guide** should **not**:

- freeze if a user clicks on buttons when the application is loading;
- freeze in general;
- show the user error messages and script code;
- be aimed at an exhibition in which visitors do not feel comfortable and through that only view quickly;
- play audio fragments the user did not asked for without a warning;
- only use the device's speaker for the audio output, as this can cause nuisance to other visitors;
- overload the visitor with multimedia information;
- push more information towards the user then he wants to receive;
- provide the user with content that can not be seen properly because of environmental influences like sunlight;
- have visible (hardware) buttons if they are not in use, because they confuse the user;
- lead to the fact that users have to walk back to the counter because for example the guide's battery is empty.

Specific guidelines

Guideline from section 2.1.3 based on challenges in delivering personalized information to visitors.

The museum's staff members and volunteers should be enthusiastic about the system.

Guideline from section 7.4 Content framework

The content of the Information Assistant is responsible of dividing the user's attention between objects and surroundings and the Multimedia Guide.

Possible ways are:

- The content (text or audio) can pinpoint the user to the object by describe a certain fact and tell the user where to look at.
- The content can tell the user things that he can see in his surroundings.
- Providing the information is small pieces instead of long texts that require attention.
- The guide can ask the user questions for which the user has to study his surroundings before he knows the answer.
- he guide can use audio instead of text or video so that the user does not have to look at the screen.

Navigation guidelines from section 9.3.3

This results in the following **guidelines**:

- The interface must have a unambiguous start page.
- It must be clear which pages have been visited.

From section 7.1.1 Guidelines for the multimedia guide's casing

Guidelines for the **casing**:

- The casing should be light weighted
- The museum's employees should be able to press the reset button, but the visitors not.
- The on/off button (on a PDA this is more a standby button) should be reachable for both, museum employees and visitors. The PDA will switch to standby if the user has not used it for an adjustable time in minutes, to save battery resources.
- All hardware buttons that are not is use should be covered by the casing.
- The casing should ensure that all PDAs used, look like they belong together.
- The casing should be made from that kind of material that can absorb impact.
- No metal should be used on the place of the GPS antenna because that will interrupt the signals; mostly this place is marked with a GPS symbol.
- The used material should not require maintenance, like leather that has to be lubricated.
- Any form of casing should be universal to any type or brand of PDA's.

From section 7.1.2 Graphical user interface, part about Bookmarking

Guidelines for a **bookmark tool**

The bookmark tool must be:

- well integrated in the visitor experience;
- advertised online and onsite and specially aimed at the committed visitors;
- visible to the visitors;
- transparent, intuitive and easy to use.

The bookmark functionality must be:

- explained , so that the visitor is aware of the functionalities it can offer before, during and after the visit;
- understood by the users.

From section 7.3.3 Registration terminal

Guidelines for the **registration terminal:**

- The inserted text has to be immediately visible on a screen; the user has to see what he or she is doing.
- People have to be able to skip the personalization step, because they must be in control of the system.

From section 7.4.1: Audio

Guidelines for audio:

- *Speech rate:* The speech rate of radio and TV newscast announcers is a good speed to employ for the spoken text.
- *Voice:* Frequencies above 4000 Hz need to be avoided; therefore male voices are a better choice.
- *Sound volume:* The user has to be in control of the volume.

From section 7.4.2: Text

Guidelines for text on active displays:

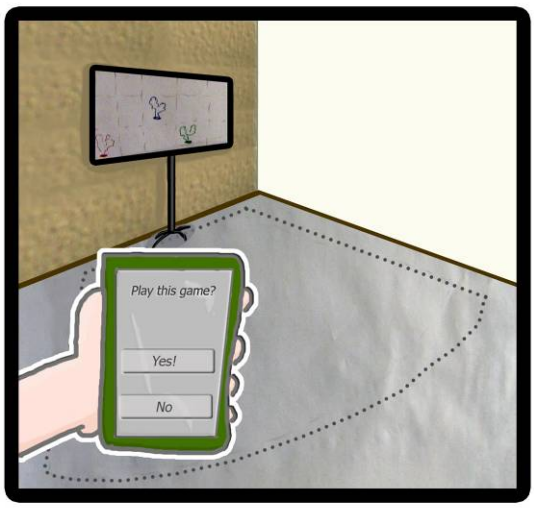
- *Font size:* For a 240x320 PDA screen, let users choose between a 12 point font size version and an enlarged version with a 14 point font size.
- *Font type:* Prefer sans serif fonts, such as Arial or Helvetica. Upper-case text can be used for titles to attract attention.
- *Font color:* Use dark characters on a light background with at least a contrast ratio of 1:3.
- *Text length:* When using vertical scrolling it is preferred to scroll fluently instead of jumping per line. Another solution for longer sections of text is paging.

From section 8.7: Use of color

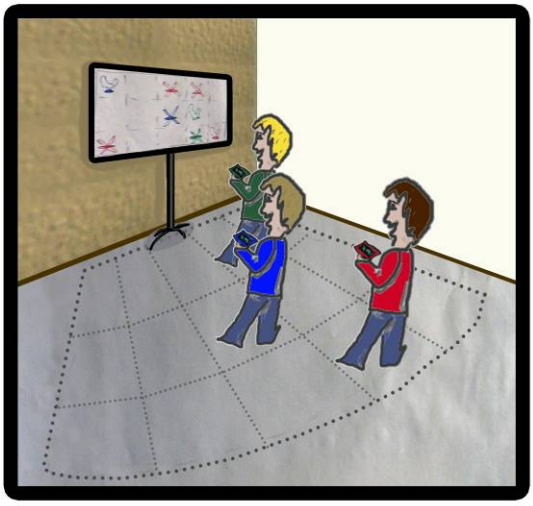
Guidelines for **use of color**

- Use color as an aid, it should not be the only differences between icons
- Check the effect of chosen colors to the color-blind by using a tool like Vischeck.
- Be careful with the colors red and green because they have strong existing associations.
- For an outdoor screen blue test on a yellow or white background could be used instead of black on white.

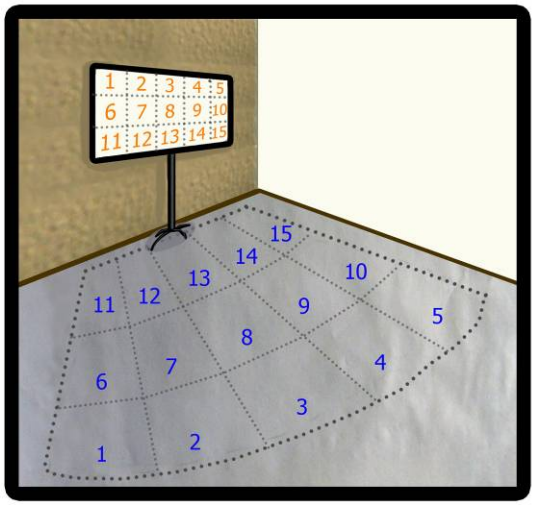
Appendix I: Games



The 'screen', on the wall, detects if someone is entering the territory. When a person points the PDA in the direction of the screen he can become a player. The game can be played with one or more players. Other persons can join in during a game and play along.

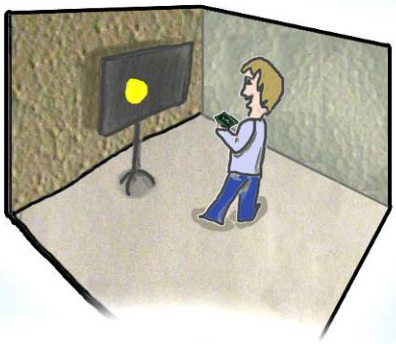


The purpose of the game is not to let the steam escape. The screen is divided into 15 areas which correspond to 15 invisible areas on the playground.
If one player plays the game, one area shows escaping steam. The player can stop the steam from escaping by standing on the right spot on the playground. When the steam is stopped at that area a new area starts releasing steam.
By a multiplayer game, every player gets a unique color and colored steam.



The working of the game is based on matching the coordinates of a player's PDA with the coordinates of the escaping steam. If a player is standing on area 8 of the playground the positioning system compares the coordinates of the PDA with the coordinates the game has to have for stopping the steam from escaping. When there's a match the player gets a colored cross at that area on the screen which means he earned a point.

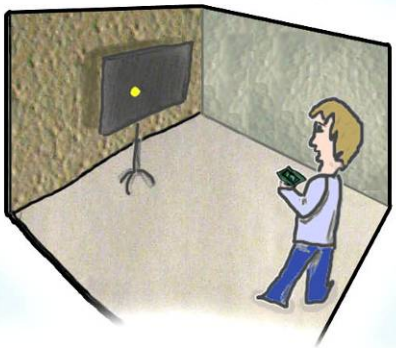
1



Patrick walks towards a big screen.

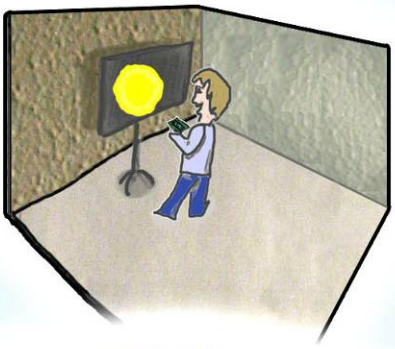
Patrick: " He, what is that?"

2



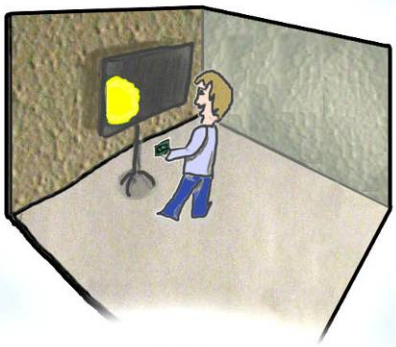
Patrick: " The yellow dot is changing size and shape when I move."

3



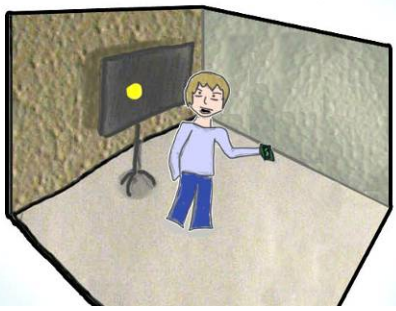
Patrick: " The closer I get to the screen, the bigger the dot becomes."

4

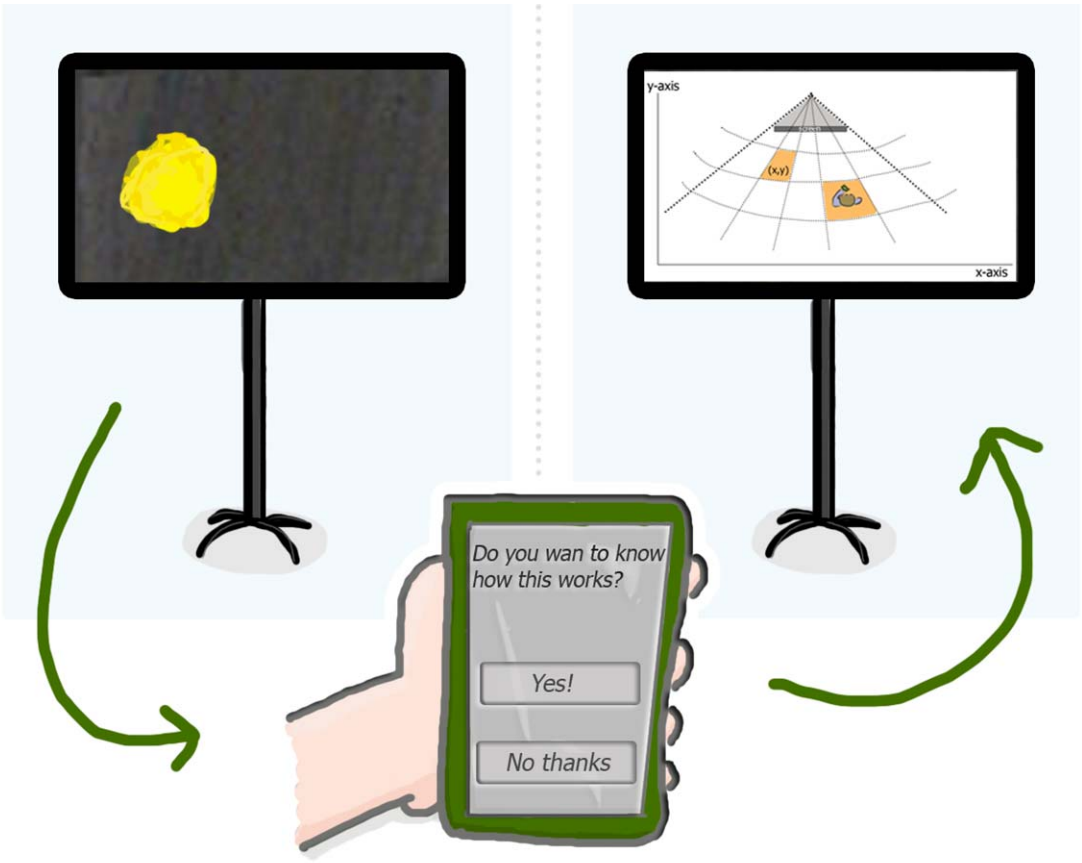


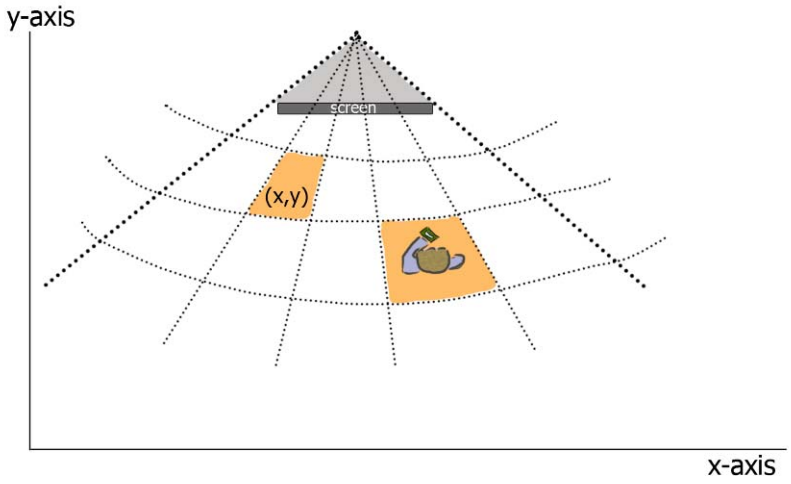
Patrick: " When I move the PDA to the left the dot also goes to the left side of the screen."

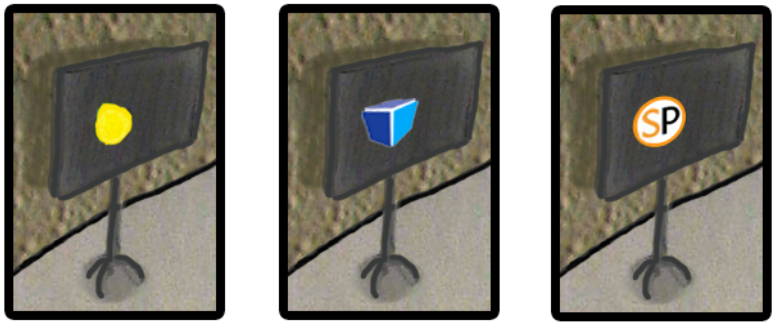
5



Patrick: " Ha, the dot is not following me, but it's following the PDA!"


y-axis
(x,y)
x-axis
Do you wan to know how this works?
Yes!
No thanks


y-axis
screen
(x,y)
x-axis



Appendix J: DorpsQuiz

PIA (Persoonlijke Informatie Assistent) neemt je mee op een speltocht door een Westfries dorp. Je kunt het spel met de benenwagen spelen, maar je kunt het gebied ook groter maken door op pad te gaan met de fiets of een ander vervoersmiddel.
Onderstaand scenario speelt zich af in het Westfriese dorp Wervershoof.

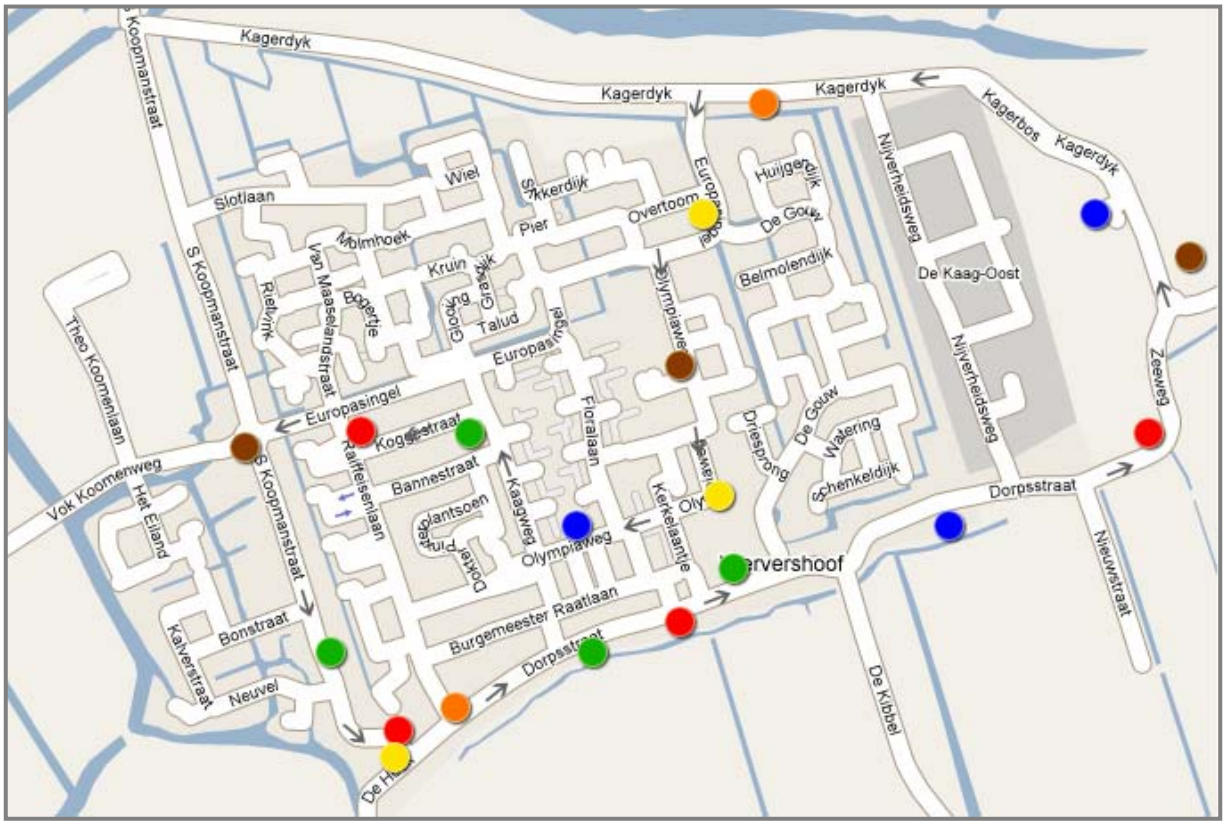
Voor het jaarlijkse familie-uitje besluit de Wervershoofse familie Schouten de DorpsQuiz van Wervershoof te spelen. De familie wordt opgedeeld in groepen van 5 mensen en elke groep krijgt een eigen PIA mee. Dit is een klein computertje (PDA) met een scherm waarop de kaart, vragen en afbeeldingen getoond worden. De getoonde tekst wordt door PIA ook voorgelezen. Het spel heeft de vorm van een triviant spel. Er zijn 6 verschillende soorten vragen:

- Vraag over een foto op de PIA en/of een dorpsgezicht (blauw)
- Vraag over het Westfriese dialect (rood)
- Vraag over de cultuur (geel)
- Vraag over sport en spel (oranje)
- Een geschiedenisvraag (groen)
- Een aardrijkskundevraag (bruin)

Bij elke soort vraag hoort een kleur, deze kleur staat als een stip op de kaart op de PDA. De vragen kunnen alleen beantwoord worden als de groep in de buurt van de stip is.

De groep van Inge (25) bestaat uit haar tante Nel (63), oom Hans (49), neef Ronald (30) en nichtje Nienke (7).

De plattegrond behorende bij De DorpsQuiz in Wervershoof:



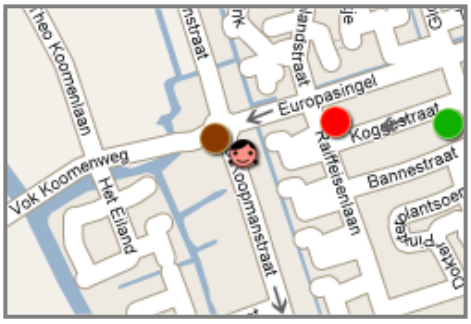
De startpunten voor elke groep liggen verspreid in het dorp zodat ze elkaar niet gelijk in de weg lopen en er een echte strijd kan ontstaan.

De groep van Inge begint bij de kruising van de Vok Koomenweg en de Simon Koopmanstraat. Op deze plaats bevindt zich ook de eerste (bruine) vraag:

PIA
Jullie lopen nu op de Simon Koopmanstraat.

Vraag: Hoe heette vroeger de Simon Koopmanstraat in Wervershoof?

A: de Lagedijk
B: de Hogedijk
C: de Gommersdijk



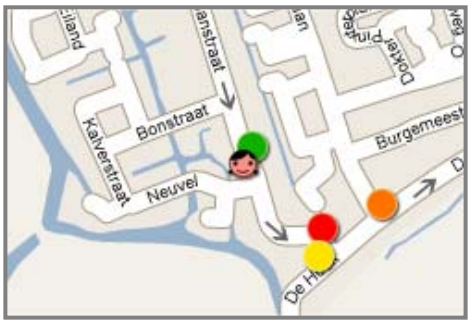
Tante Nel weet het antwoord wel maar houdt nog even haar mond. Nienke heeft geen idee maar gokt op de Hogedijk. Inge en Ronald weten dat Wervershovers Gommers genoemd worden, maar weten niet waar die naam vandaan komt. Hans weet dat de Simon Koopmanstraat vroeger een dijk was en dat deze waarschijnlijk lager lag dan de Westfriese omringdijk. 'Het heette vroeger inderdaad de Lagedijk' zegt Nel. Inge klikt op A en het antwoord is inderdaad juist. PIA legt ze uit waarom.

Ze lopen verder over de Simon Koopmanstraat en komen bij een gebouw dat vroeger gebruikt werd als Slagerij. Hier staat een groene stip.

PIA
Dit is een van de oudste nog bestaande panden van Wervershoof.

Vraag: Hoe oud zijn de eerste sporen van menselijke bewoning in West-Friesland, die men heeft gevonden?

A: 1000 jaar
B: 5000 jaar
C: 15000 jaar



Dat is een moeilijke vraag, ze weten het niet. Inge mag kiezen en kiest voor antwoord A. Dat is onjuist het had B, 5000 jaar moeten zijn. PIA vertelt.

De Schoutens lopen verder en komen uit bij 'De Hoek'. Ze komen al dichter bij de rode stip, Inge klikt hem aan.

PIA
Jullie staan nu in 'De Hoek' hier staat eens per jaar de kermis.

Vraag: De uitdrukking ' 't bloift gien kermis,' wul zegge...?

A: er komt eens een eind aan
B: dat kan ik niet meer betalen
C: jammer dat het afgelopen is

Zelfs Nienke weet het antwoord op deze vraag, ze heeft het haar vader wel een horen zeggen als ze vroeg om nog een snoepje.
Inge klikt antwoord A aan en dat is goed, PIA legt uit waar de uitdrukking vandaan komt.

Naast de rode stip staat ook een gele stip op de kaart, Inge klikt deze aan.

PIA
Jullie staan voor café/dancing Van Rooijen en lopen zo meteen over de dorpsstraat richting de kerk.

Vraag: Voordat vroeger het bruidspaar van café naar kerk vertrok, at men witte bollen en krentenbrood; wat zat er op de bollen?

A: ham
B: honing
C: muisjes

Niemand weet het antwoord, volgens Nel en Hans was het in hun tijd allang niet meer zo dat er standaard bollen en krentenbrood gegeten werd. Nienke en Inge denken dat het honing is, omdat dat erg zoet is en dat heeft dan vast iets te maken met trouwen en liefde denken ze. Helaas, het antwoord is onjuist het was A, ham. PIA vertelt wederom hoe het zit.

Volgens de route op de kaart moeten ze de dorpstraat inlopen, even verder bij de kruising met de Raiffeisenlaan staat een oranje stip. Inge klikt de stip aan als ze op de locatie zijn aangekomen.

PIA
Jullie passeren de Raiffeisenlaan, in deze laan bevindt zich de finish van de jaarlijkse wielerwedstrijd.

Vraag: Hoe heet de wielerwedstrijd waarmee de Theo Koomen Plaquette gewonnen kan worden?

A: Dorpenomloop
B: Theo Koomen plaquette
C: De wielerronde van Wervershoof

Gewoon de wielerronde van Wervershoof inderdaad roepen Ronald en Inge. Ze gaan er elk jaar heen, niet voor de wielrenners maar voor het vermaak in ‘De Hoek’. Vaak speelt er een band en staat er een bar. Volgens Hans heeft de wielerronde wel degelijk een naam, het heet de Dorpenomloop. Dat is het juiste antwoord en gelukkig heeft Inge naar haar oom geluisterd en A aangeklikt.

Terwijl ze de Dorpsstraat af lopen komen ze een groene stip tegen.

PIA
Jullie staan voor nummer 27, voorheen zat hier Bakker Holland.

Vraag: Wat betekent de naam Holland?

A: houtland
B: diep liggend land
C: leeg land

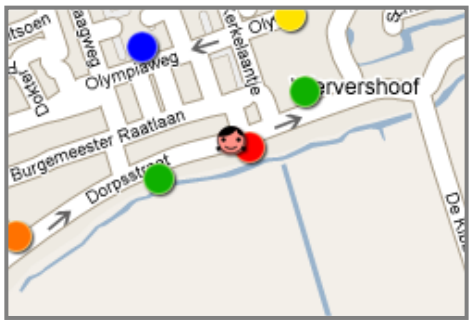
‘Hollen voor het water’, roept Ronald, volgens mij is het diep liggend land. De rest denkt er net zo over, ze kiezen dus voor B. Helaas is dit fout het had A, houtland moeten zijn. PIA legt uit waar de naam Holland vandaag komt.

Een klein stukje verder staat een rode stip op de kaart. Inge klikt hem aan op het moment dat ze er nog niet zijn. PIA geeft aan dat ze er eerst heen moeten lopen.

PIA
Hier volgt een taalkundige vraag.

Vraag: Wat is stroffele?

A: schoffelen
B: straatvegen
C: struikelen



“Ja, struikelen natuurlijk” zegt Inge, “is dat geen Nederlands dan?” Alle vijf weten ze het goede antwoord te noemen.

De Schoutens komen aan bij de kerk van Wervershoof. Bij de kerk staat een groene stip.

PIA
Jullie staan nu voor de Sint Werenfriduskerk, daarachter ligt de begraafplaats.

Vraag: Hoe oud werden in de bronstijd de mensen in West-Friesland gemiddeld?

A: 35 jaar
B: 45 jaar
C: 55 jaar

Dat is allemaal erg jong merkt Nienke op, oma is 86! Inge vraagt zich af wanneer de bronstijd ook alweer was. Niemand weet het met zekerheid te zeggen. Ze gokken op het middelste antwoord, B. Dat is helaas fout gegokt het had A moeten zijn. PIA vertelt ze waarom mensen in de Bronstijd niet zo oud werden.

Inge klikt de blauwe stip in het scherm aan. PIA toont ze nu een foto.

PIA
Jullie staan nu voor Dorpstraat 38, voor de timmerwerkplaats van Niek van Dijk.

Vraag: Deze foto toont de functie van dit pand in 1920. Wat was het?

A: een woonhuis
B: een boerderij
C: een timmerwerkplaats

Geen van alle weten ze zo het antwoord. Iedereen komt om Inge heen staan zodat ze een voor een de afbeelding kunnen bekijken. Nienke ziet dat de jongen links een zaag in zijn hand heeft. Hans zegt “misschien is het wel een strikvraag en waren die jongens gewoon aan het werk aan het woonhuis of de boerderij”. Inge merkt op dat ze allemaal iets in hun hand hebben en ze zo waarschijnlijk laten zien dat ze timmermannen zijn. Ze kiezen dus voor antwoord C. Het antwoord

is juist. PIA vertelt dat dit het Timmerbedrijf is van Piet Groot. Links op de foto staat timmerman Piet Groot, de leerling en de knecht op de trap zijn onbekend, rechts staat de zwager van Piet Groot, Jan de Haan.

Ze lopen richting de Zeehoek en komen een rode stip tegen.

PIA
Jullie zijn nu aangekomen in de Zeehoek.
Vraag: In 2005 werd 'te warskip' als mooiste Westfries woord gekozen: wat betekent het?

A: uit logeren
B: aan het oppassen op kinderen
C: uit varen

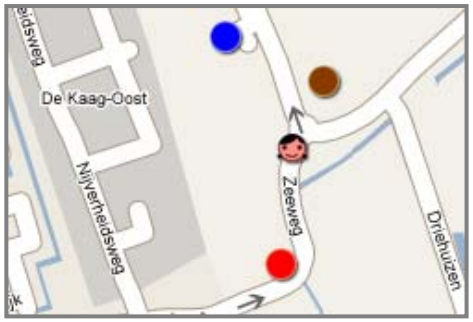
Alleen Nienke heeft nog nooit van deze uitdrukking gehoord. Nel en Hans gebruikten het woord vroeger als ze uit logeren gingen. Inge en Ronald hebben het woord nooit gebruikt maar kennen het wel. PIA legt uit waar het woord vandaan komt, dat weten ze alle vijf niet.

Nel, Hans, Ronald, Inge en Nienke zijn aangekomen bij de dijk. Bovenop de dijk staat een bruine stip, hiervoor moeten ze eerst het trapje oplopen.

PIA
Jullie staan nu bovenop de dijk en kunnen het IJsselmeer zien liggen.

Vraag: Wat voor soort water had het IJsselmeer toen het nog het Almere was?

A: zout
B: zoet
C: brak



"Het heette toch de Zuiderzee" zegt Ronald, en dat was zout water. Nel vertelt dat Almere staat voor 'een groot meer', wanneer dat meer er lag weet ze niet. Dan was dat vast brak water denkt Inge. Hans en Nel denken beide dat zoet het juiste antwoord is. En omdat ze nou eenmaal de oudste zijn gaat de rest daar in mee. Inge klikt antwoord B aan, dat was inderdaad het juiste antwoord. PIA vertelt ze over Almere.

De familie Schouten volgt de route en beantwoorden de vragen tot ze weer aangekomen zijn bij het startpunt. Nu gaan ze naar Café Van Rooijen. Een deel van de familie zit daar al, die waren eerder klaar. Het is wachten op de rest. De PDA's worden ingeleverd en wanneer iedereen binnen is wordt de uitslag bekend gemaakt. Het groepje van Inge heeft helaas net niet gewonnen. Er wordt flink nagepraat en het blijkt dat het spel makkelijker was voor de ooms en tantes omdat zij meer weten over het Wervershoof van vroeger. Er wordt verteld dat iedereen het spel kan aanvullen door nieuwe vragen aan te dragen via de website van het spel. Ronald en Inge verzinnen alvast een paar vragen over de handbal vereniging waar ze beide lid van zijn.

Bron vermelding:
De vragen (behalve die over timmerbedrijf Groot) zijn overgenomen uit het Westfrieslandspel (bordspel) van Tom en Gerda Wester-Koomen.
De foto komt uit het archief van de Stichting Oud Wervershoof.

Appendix K: Cd-rom

Data from interface concept evaluations,

user tests,

content test,

map test,

Interviews with possible users,

The Virtual Museum presentation,

A questionnaire and observation aspect list for a user test at the museum.