Redesigning the Information Systems at the Swedish National Museum of Science and Technology

DM2624 Project Report 2022

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1 Introduction

Museums today lack many of the aspects that create an accessible and inclusive experience for blind and partially sighted visitors. Exhibitions are often limited in ways that visually impaired people cannot get a full experience [6, 8], and information systems are more often adjustable for the sighted user in mind.

This project is centered around redesigning the information systems at the MegaMind exhibit of the Swedish National Museum of Science and Technology. Using an iterative design process and user evaluation we will redesign the information system so that it is better accessible to people with visual impairments. By that, we refer to anyone with any degree of visual impairments.

The intended outcome is to arrive at an improved design for the information system that is experienced as easier to use and more accessible than its predecessor for people with visual impairments. The study aims to answer the following research question:

How can the physical attributes of the information system at the Swedish National Museum of Science and Technology be better designed for the visually impaired in terms of accessibility?

1.1 Background

Disability has historically been viewed through different lenses, going from a 'medical model' towards a 'social model' and 'biopsychosocial model' [5]. A brief summary of the models follows. The medical model focuses on describing disability with an emphasis on the individual, their medical diagnosis and deviation from the 'normal' being the issue. The social model makes a switch away from the individual and describes disability as the limitations imposed by the physical and social environment. The biopsychosocial model is a middle ground between the other two, trying to incorporate biological, individual and societal perspectives. WHO's International Classification of Functioning (ICF) provides a framework for describing disability as a multidimensional concept through the biopsychosocial model [3]. Following the ICF, this study aims to identify and dismantle the environmental barriers of the information systems for all visitors at the museum, but focusing on user groups with impaired sensory function of seeing, such as blindness.

Colors and contrasts are important aspects to consider. Black and yellow is one of the best color combinations, seeing that it contributes with both good contrast, as well as being visual for color blind people. Layout of buttons are also something to consider when it comes to accessibility for people with reduced visual fields. It can be hard for people with this kind of impairment to navigate displays with layouts that have widely spaced controls [1].

Seeing that visual cues sometimes are hard to detect by people with a degree of visual impairment, it is important to incorporate other types of cues in designs, such as sound or haptic [10]. Braille text should always be available and be supplemented with pausable speech output, equipped with a volume control [9].

1.2 Ethical considerations

There were some difficulties with finding people from our user group that wanted to participate in the evaluation of our prototype. Eventually we had to resort to simulated user evaluations, where we asked our fellow classmates to attempt to navigate our prototype whilst their eyes were closed. However, this approach is by no means interchangeable with evaluating using persons with visual impairment. It can be seen as unethical and result in faulty outcomes [7]. Furthermore, this type of testing meant that we were only able to test on people with complete, simulated, blindness, and not different degrees of visual ability.

1.3 Contributions

Most of the work has been done not as separate individuals, but as a group. We all worked together to sketch and build the prototype, and we all participated in the user evaluation, reworked the design and discussed the results together.

2 Method

2.1 Visiting the museum

To start off the design process we visited the Swedish National Museum of Science and Technology, specifically the MegaMind exhibition. There we got ourselves familiar with the current information system, and noted down all the flawed design choices, with visually impaired people as our target group in mind.

2.2 Designing the new information systems

We set out to sketch a redesign of the physical aspects of the information system. Even though the information system was lacking in the screen interface as well, we decided on focusing on only the physical design. Several sketches were created and iteratively improved (see appendix 1 for pictures of some sketches). After the sketch phase, we decided on a prototype to construct. The prototype was a lofi version of the hypothetical finished product, made out of cardboard and other cheap materials. The finished prototype can be seen in the picture below.

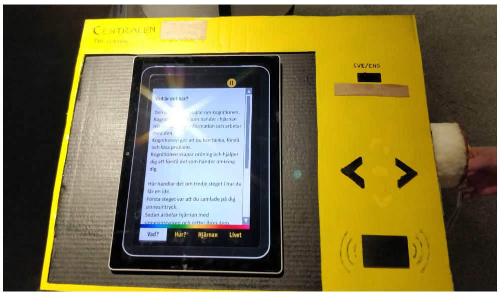

Figure 1. Finished prototype

In order to make use of high contrasts, the prototype was colored in black and yellow. The panel of the information system was made bigger, so that the physical controls could fit on it and be placed spaciously, making them easy to distinguish. All the controls were gathered on the same side of the panel, so that the layout was simple to navigate. Braille was used wherever text was written on the panel. A physical switch was used in order to change language, making it simpler to perform the action even with low or no vision.

The headphones were placed on the side of the panel instead of the pole, in order to make them easier to detect and let the user avoid having to bend down. The sound was controlled by a joystick on the headphones, that could alter the volume as well as play and pause. Sound effects and screen readers were simulated to be activated when pressing buttons, and the sound was emitted through two earphones stuffed in the prototype headphone.

A feature of the prototype was that the user could simulate scanning their phone on the information system, using NFC technique, in order to make the system change after predetermined preferences (such as language). This would make it possible for the visitor to decide the settings before the museum visit. A sound cue was used in order to simulate the NFC scanning of the mobile. Lastly, a prototype of tactile paving was made to make it easier to navigate to the information system itself.

2.3 User tests

The user testing took place at the Swedish National Museum of Science and Technology. The participants consisted of 5 master and bachelor students taking the course *DM2624 Human Centered Technology for Disabilities* at KTH, and were between the ages 22 and 30. The participants were introduced to the task without knowing the appearance of the prototype, but the majority had previously tried the current MegaMind information systems at the museum. They were told to think aloud while performing the user test and a 'Wizard of Oz'-approach was taken during the testing.

The participants were first given information about the system that simulated information that would be given at the reception to a visitor with a visual impairment. The information given was that the headphones were located on the right side of the information system, that the NFC-scan to transfer your preferences were located at the bottom right corner and that the system had different information topics which you could switch between.

Three different scenarios (see appendix 2) were presented by a moderator, each one after the other. The tasks were explored in the participant's own tempo but if they got stuck, help was given by the moderator so that the scenario could progress. To conclude the user evaluation, the participants got to answer a couple of questions about the experience and the prototype.

3 Results and Analysis

The data from the observation and interview were analyzed with an inductive thematic analysis [4]. The coding was done on a semantic level with categories and themes emerging latently. The resulting overall view of the number of codes for each theme and category can be seen in Table 1. The analysis resulted in six main themes, each described in their own headings below. The themes are supported with data extracts from the observations and interviews. The extracts have been translated from Swedish to English and grammatically corrected by the authors.

Theme	Category	Nr. of Codes
Transferring settings with NFC	Hard to find	2
	Easy to find	2
	Confusing interaction	8
Locating the Headphone	Hard to find	4
	Easy to find	5
Navigating the Pages	Hard to navigate	8
	Easy to navigate	8
The Language Button	Hard to find	2
	Easy to find	3
	Confusing	2
Hard to Find Braille Text		3
Confusing button on headphone		15

Table 1. Overview of themes, categories and codes

3.1 Transferring settings with NFC

The majority of the data in this theme indicate the users were confused about how this interaction worked. Participant 3 stated that it was "Nice to use the mobile but a bit unclear if you were required to keep the mobile there or just blip it once." Participant 4 simply said they "Was confused by the NFC. The blipping was clearer thanks to information received beforehand." Furthermore, some participants found the NFC spot, where to blip, easily while some struggled. The tactile contour of the NFC spot was confused for a QR-code by Participant 2 who said "The NFC was mistaken for a QR-code but the shape is perfect."

This indicates that the interaction of the NFC may need to be redesigned. The interaction assumes, however, that the user already has acquired some knowledge of the system beforehand as they need to have adjusted their accessibility preferences in their mobile, through an application. The results can indicate that some participants did not understand or remember the instructions given about the NFC, thus being confused about how it worked and where to 'blip'.

3.2 Locating the headphone

The analysis showed that the majority of the participants did not experience any issues with finding the headphone. However, one participant was observed struggling a lot and was given a verbal reminder of how to find it. When asked if an auditory signal from the headphone would be helpful in finding it, all but one said that it would be unnecessary as the headphones were easy to find. One participant suggested that haptic feedback in the form of vibrations could be better.

The analysis suggests that the design was good enough in facilitating the participants in finding the headphones, but that the use of another cue than visual would be helpful.

3.3 Navigating the pages

There was an equal amount of both negative and positive feedback in regards to the way in which the user navigates through the pages. While some users found the arrow buttons intuitive and easy to use, others struggled a bit more. Two participants noted that it was difficult to navigate the system with one hand, as the other was occupied with holding the headphone. Another participant desired a different kind of navigation and suggested that voice activation could be a better option. The participants that found the navigation positive reported that the arrow buttons were designed in such a way that their purpose was very clear, as illustrated by Participant 2 stating that "[...] it was straight-forward to figure it out, the arrows are kind of obvious.".

3.4 The language button

In regards to the language button, the feedback varied a lot. While most participants found the switch intuitive, its location was difficult to find. Most users reported that this was due to the fact that they could not find the braille text that explained the switch's function.

3.5 Hard to find Braille Text

It was difficult for some participants to find the braille text on the information system. Participant 3 suggested that it would be preferable to have the braille text at the bottom of the information system.

3.6 Confusing button on headphone

All participants found the button on the headphone confusing, specifically how to adjust the volume. Many of the participants needed guidance on how to adjust the volume. Three of the participants said that they would have preferred to spin the button in order to adjust the volume. One participant said that it was not necessary for the user to adjust the volume. Two participants also preferred the pause/play button to be on the panel instead of the headphone.

4 Discussion

In this study we aim to answer the research question: *How can the physical attributes of the information system at the Swedish National Museum of Science and Technology be better designed for the visually impaired in terms of accessibility?* Conducting research through design, with a user-centric approach the question would be investigated by re-designing the physical interface. Some criterias for a better design were brought up in section 1.1, being that (1) colors should be contrasting, (2) layout of buttons not spaced too widely, (3) give feedback in other sensory modalities than vision, and (4) supplement text with braille and/or speech output with adjustable volume. A low fidelity prototype was designed with these criterias in mind and user evaluated with a Wizard of Oz and Think Aloud approach in which data was collected through notetaking of observations and interviews. The key findings in the thematic analysis of the results were formed as six themes (see Table 1). These themes can partially answer the research question posed. Partially as the question itself is, to a certain extent, open ended. The continuing discussion revolves around the themes, attempting to infer on the research question.

4.1 Transferring settings with NFC

NFC is a technology used for easy wireless data exchange over short ranges and is increasingly used by devices in society [11]. NFC has the possibility of increasing the accessibility for visually impaired in several ways. One example is a study investigating the use of NFC for 'smart labeling' in a museum [12] where users would hold their mobile phone close to an object and get audible information on it. The range of NFC is around 4cm [13], requiring the user to pinpoint the transfer location. In our prototype the NFC mechanic was designed as an easy way for users to quickly change the settings of the information system by holding their mobile phone close to an area located at the bottom right on the interface (see Figure 1 for reference). The theme describes this interaction as being smooth for some participants and that others struggled. Possible obstacles were unclear, or hard to remember, instructions about the mechanic and confusing tactile feedback from the NFC location. This suggests that the design was partly successful but could be improved. The tactile feedback could be made even more obvious as the NFC location included a big black protruding rectangle which is easily confused as a button. The NFC location could also be supplemented with braille text.

This mechanic allows visually impaired users to independently engage with the information systems as the default settings may create a barrier for this user group. User groups that are less likely to have mobile phones (e.g. young children or elderly) could still be included in the design by providing them with a physical NFC tag, pre-set to their preference at the reception.

4.2 Locating the headphone

A headphone was placed on the right side of the interface, with the argument that it would be easier to find than in the original interface that had it placed underneath the interface. A first-time user exploring the interface with solely their hands would hence be more likely to find the headphone. This theme describes how all but one participant easily found the headphone, supporting the design choice. The one participant struggling to find the headphone could be the result of the prototype headphone being made in cardboard and upholstery foam as opposed to plastic and metal that real ones usually are made of. Therefore not being recognized as a headphone as the participant explored the interface with their hands. However, if the headphones are not repositioned at their intended place, users could still struggle to find the headphone. Providing an extra cue of the headphones location through haptic or auditory feedback when a user approaches could solve this.

4.3 Navigating the pages

The original interface was solely interactable through a touchscreen, making interactions very hard for users with no vision. This theme shows that by introducing physical buttons shaped as arrows they give off the affordance, an intuitive understanding, of being used for navigation. Suggesting the design improved the accessibility of navigating the information system's pages. The biggest issue participants experienced was that they needed to hold the headphone with their right hand while simultaneously pressing the physical buttons, located on the right-hand side of the interface, with their left hand. The design could, hence, be improved by either placing the buttons on the left-hand side or using a headphone that does not require the user to constantly hold them. With the latter prefered as it could also assist users with motor impairments.

4.4 The language button

If the user did not change the system settings using the NFC mechanic a big barrier in changing it on the interface itself could be the language. Therefore a dedicated physical language button was added to the interface. This was a binary flip-switch, representing English on one side and Swedish on the other. The theme describes it as being intuitive in use but hard to find for the participants. Intuitive perhaps as the result of directly getting feedback on the audio changing language and the tactile feedback of its binary functionality. The issue of finding the button is explained as due to difficulties finding the braille text, which is discussed below.

4.5 Hard to find Braille Text

This theme was small in terms of associated codes, but is an important insight in designing for our targeted user group. This issue could be a result of solely using participants with 'simulated' blindness. The participants were probably not used to reading braille and they might not recognize it when touching it. But it could also be the result of the surface of the prototype not being smooth, with 'bumps' after having been spray painted, in conjunction with the braille text not being raised enough. The theme also notes that the braille text positioned at the top left did not get read by the participants as their hands never explored this area. Thus, an important insight is to place important braille text in areas the users are expected to place their hands. The original interface had its braille text at the bottom, below the screen, which may be a better place.

4.6 Confusing button on headphone

The final theme describes issues with the button on the headphone. This was an extruding spring-push button with five interactions. It could be pressed inwards and pushed in four directions, up, down, left and right. Pressing it inwards was mapped to play/pause of audio while pushing up/down adjusted the volume. The reason for having buttons on the headphone was that several users, each with their own headphone, would separately be able to control and adjust the audio. Adjusting the volume was the most confusing part, with the participants trying to spin the button in a twisting manner. This may suggest that the button afforded twisting or that the participants' mental map of adjusting the volume is to twist the button. The best way to design these interactions should be tested in future designs. One possible solution would be to have one binary spring-push button for play/pause, and one scroll wheel for adjusting volume. Lastly, the theme does not say that the button was hard to find. As the button was very distinguishable in its physical size, it was probably noticed by the participants the moment they grabbed the headphone. Suggesting the design succeed in this regard.

4.7 Methodological critique

A short evaluation of the accessibility of the original interface for the information system would have been beneficial in argumenting for how or if the new design improved the accessibility. This could have been done by a heuristic evaluation with a list of criteria established based on previous research and guidelines. Following a brief description of the original interface and what criteria it fails to fulfill.

Furthermore, the results of the user evaluation had many contradictions. Half of the participants found something easy and were successful in some interaction while the other half had issues with the same. This could be the result of too few participants. The results would also be more credible if the user evaluation had included participants with actual visual impairments as simulating blindness can result in misleading information [7]. However, the study is not making bold statements and the study is to be considered the first step in a longer process of designing the information systems. In this regard the findings of this study are useful for anyone who would continue the process or begin a similar endeavor.

4.8 Implications and future research

The findings may be of value to designers and researchers attempting to develop similar interactive information systems. A continuing study could use the findings and design a higher fidelity prototype to test on participants with visual impairments. However, just the findings of this study by itself could also be of value to museums as it could be used when requisitioning new information systems.

5 Conclusion

This study focused on re-designing an information system at a museum in terms of accessibility for people with visual impairments, focusing on the physical attributes of the interface. A low fidelity prototype was developed and user tested. The findings can be seen as six design considerations, not as strict rules. Firstly, if NFC technology is used, the physical NFC spot should be identifiable by feeling a distinguishable shape and braille text. Secondly, any headphone should be placed where a user without vision exploring the interface with solely their hands will feel the headphone. The headphone should preferably not be required to be continually hand-held. Thirdly, arrow-shaped buttons are intuitive for navigating the digital interface. Fourthly, a binary flip switch is intuitive for changing between two languages. Fiftly, braille text in arbitrary locations may be missed. Sixthly, if buttons are placed on the headphone they should be easily felt and have an intuitive mapping.

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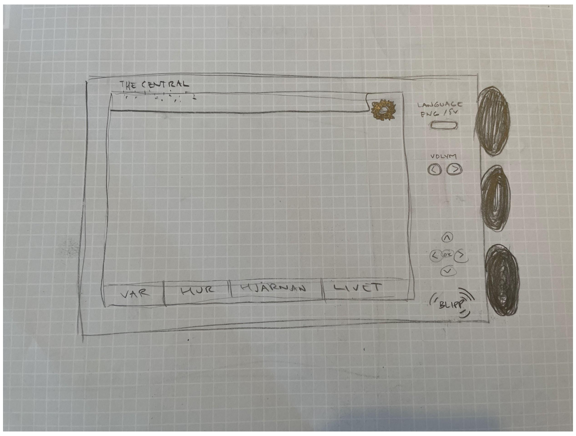
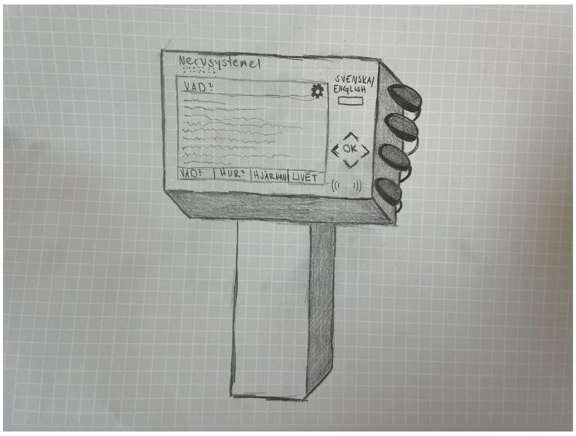
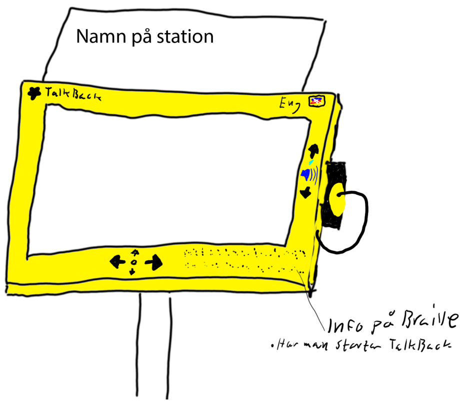
APPENDIX 1 - Sketches of prototype







APPENDIX 2 - Scenarios

Scenario 1:
Before your visit to the museum, you have set your settings after your visual impairment. These settings are saved in the mobile and can be transferred to the information system through NFC. You have been told at the reception that the NFC scanning area is placed at the bottom right corner of the information systems.

Now we want you to find the Central information system and change the settings to your preference using your mobile.

Scenario 2:
Now we want you to find a pair of headphones and push play to start listening to the text that is currently on the screen. Also alternate the volume after your preferences.

Scenario 3:
This time, we want you to specifically listen to the page “Brain”. Please, also change the language.