
IBEACONS FOR CONCORDIA

EXPLORING THE POSSIBILITIES OF IBEACONS IN A MUSEUM CONTEXT

Creative Technology Bachelor Project
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ABSTRACT

This project explores the possibilities of iBeacons as a tool for museum visitor experience improvement for Concordia. Design guidelines for applications in a museum context were collected using literature research. Based on these guidelines and requirements, a functional application prototype was created and tested.

The prototype that was created is a self-guided tour application for android. This application lets visitors explore and learn at their own pace, by offering a selection of different tour lengths and art information selections. The app helps visitors orientate using an interactive map of the museum. In addition to these features, visitor navigation in the app is simplified or fully automated using iBeacons.

After realisation, the app was tested multiple times, and final testing was done in Concordia was done with real visitors. These visitors were asked to rate their change in visitor experience based on several elements. They could rate these elements from “worsens the visitor experience”, to “improved the visitor experience”. On average, visitors reported a positive change in most of the elements of their visitor experience. Some elements were reported to be uninfluenced by the application, but on balance no negative effects were reported. This suggests that the application is successful, and improves the visitor experience in Concordia.

CONTENTS

Abstract.....	3
List of Figures.....	6
Acknowledgements.....	7
1. Introduction.....	8
2. State of the art.....	10
2.1 What kind of museum visitors are there?.....	10
2.2 What factors influence whether a target group visits or not?.....	12
2.3 What are concordia's needs and desires?.....	13
2.4 What are the possibilities of ibeacons?.....	15
2.5 How can these factors be used in product design?.....	17
2.6 Conclusion.....	19
3. Ideation.....	21
3.1 Self guided tour.....	22
3.1.1 Basic Concept.....	22
3.1.2 Possible improvements to the self-guided tour.....	23
3.2 Artists vision/work in progress'.....	25
3.2.1 Basic Concept.....	25
3.2.2 Possible Improvements to Artists vision/work in progress'.....	26
3.3 Final concept selection.....	26
4. Specification.....	28
4.1 Experience Specification.....	28
4.2 Early prototypes.....	29
4.3 Functional specification.....	30
4.4 Concept design.....	33
4.4.1 General elements.....	33
4.4.1 Specific app screens and elements.....	35
5. Realisation.....	40
5.1 Navigation:.....	40
5.2 Landing page:.....	41
5.3 Tour overview:.....	43
5.4 Map overview:.....	44
5.4.1 Custom Layout.....	44
5.5 Art interfaces:.....	46
5.6 Overview interface:.....	47

5.7 Adaptability:.....	49
6. Validation.....	51
6.1 Preliminary User test.....	51
6.2 Visitor user tests.....	55
7. Conclusion	59
7.1 Research Questions.....	59
7.2 Limitations and future work.....	60
References	62
Appendix.....	64

LIST OF FIGURES

Figure 1: Barchart of Concordia's Visitor motivations	15
Figure 2: Prototype of self guided tour art page.....	22
Figure 3:prototype of self guided tour events	23
Figure 4 Prototype of Artist's Vision app	25
Figure 5: Condensed overview of app navigation.....	35
Figure 6: Complete app navigation flowchart	41
Figure 7: interface Development of Landing page.....	42
Figure 8: Interface development of tours page.....	43
Figure 9: Interface development of map page.....	45
Figure 10: Art Page interface elements	46
Figure 11: Contents of Overview/menu page.....	48
Figure 12: Proof of concept for adaptability form	49
Figure 13: Means of visitor experience element ratings	56

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1. INTRODUCTION

In this paper, a CreaTe graduation project featuring the applications of iBeacons in a museum context is discussed. To get a better understanding of the project, its situation, problem statement, and approach used are discussed in this chapter.

SITUATION

Museums conserve and display countless artistic, historical, or cultural objects that are of value to humanity. Despite their value to society, people, young adults especially, are losing interest in museums. It is suggested that this is mainly because they see museums as stiff, boring places that are out-dated. Technology is one of the fastest changing things in the world, so museums tend to get most out-dated from a technological viewpoint. By finding innovative ways of using technology in a museum context, we can 'update' the museum and possibly draw more visitors.

iBeacons are an excellent example of new, innovative technology. iBeacons are Bluetooth Low Energy (BLE) devices that broadcast identifiers to nearby portable electronic devices, that can then be picked up by compatible operating systems or apps. The portable device's location can also be determined by analysing nearby beacons' signal strengths. Using these features, many interactive applications can be created.

Concordia is a film, arts, and theatre centre in Enschede that wants to know more about the range of possibilities of iBeacons for their exhibitions. Concordia wants to introduce as many people to the arts as possible. Concordia does this by providing a large collection of art types; exhibitions, theatre, performance art, and film. Now they want to explore if using technology could also help them achieve this goal. They would like to have at least one working application where they can adapt the content of the application themselves to make it suitable for multiple exhibitions.

PROBLEM STATEMENT

While the main challenge is to do research into possible concepts, and build one application, the underlying design considerations are just as important. We want to develop an application that is suitable for just about everyone. We want to make sure the frequent visitors keep coming, while also drawing non-visitors in. Understanding the factors of why people choose to visit, or to stay away from museum is a complex issue. Exploring how technology can help us address or satisfy those widely different desires and needs, is just as challenging

The application needs to not only be fun for visitors, it also needs find a right balance between application and exhibition. All exhibits are set up with a certain concept in mind, and if the designed application disturbs this setup, this could change the exhibit for the worse.

APPROACH

These are my research questions, which I'll be tackling with the following approach. First, in the 'state of the art' chapter, literature research will be done to gain further understanding about museum visitors, visitor experience, and factors influencing whether people visit or not. This will be done using the following research questions:

- What kind of museum visitors are there?
- What are the differences in their visitor experiences?
- What factors influence whether an individual visits a museum?

Design questions; based on this research, concepts and designs will be made using the Create design method and iterative design practices. In order to give these concepts a higher chance of success, the following questions must first be answered:

- What are the design possibilities of iBeacons?
- How can the factors found in the research phase be used to make a more successful product?

After this, the concept was realised and the developed prototype underwent validation. Tests were done with potential users to streamline the in-app experience in order to prepare for real testing with real visitors. The main research question here is:

- Is the developed product user friendly and easy to navigate?

Using the feedback from this formal test the prototype was improved to its final version, and visitors were asked to use the prototype and review it after use, using a survey. The research question of this survey is:

- Does the developed product improve the visitor experience?

2. STATE OF THE ART

Technology is constantly changing, and it is almost impossible for institutions and companies to keep up with such fast developments. Museums are one of these institutions that play a different role in society now than they did before; they are unable to keep up with technological advancement and they get out-dated fast. Due to this, interest in museums is dropping, especially amongst the young adults, who show almost no interest whatsoever [1]. Museums could benefit from having more information of how to adapt to the changing technological environment. Therefore, the main objective of this chapter is to find out what visitors look for in museums, and how these factors can be used to create a more successful product. Because of the nature of this project, Concordia's needs and Concordia's visitors will also be analysed. The design product could then be used to generate more interest in museums, and draw more visitors.

In order to do this, the following research question will be discussed: "What are the design guidelines when trying to increase interest in museums?"

The chapter will be started by analysing the different types of visitors, and exploring their needs in a museum. Then, Concordia's needs and its visitors will be discussed, as well as existing iBeacon applications. Afterwards, how these factors can be used in a product to create design guidelines for products in museums will be discussed.

2.1 WHAT KIND OF MUSEUM VISITORS ARE THERE?

Visitor group differentiation in this chapter will not be done based on demographics, but on individual sociological factors and motivations. When sorting visitors into groups, most researchers and museums are automatically inclined to sort them into demographics, however Falk [2] and Hood [3] suggest that this does not give a useful insight in why they visit, and is therefore not useful for further research. Every visitor comes to a museum with a unique motivation and expectation, but several researches have identified overlapping patterns in these motivations that can be used to gain an insight in visitors.

Falk's [2] research suggests museums visitors should be looked at based on their entry narrative. There are five subsets of entry narratives that sum up most of the museum visiting public. Falk defines five visitor types and their underlying motivations: Explorers, who are curiosity driven and have a generic interest in the content. Facilitators, who are socially motivated, and want to enable the learning or enjoyment of their social group. Professionals, who feel a close tie between museum content and their own interests. Experience seekers, who see museums are important destinations, and the Rechargers group, who want a spiritual and restorative experience.

Sheng and Chen [4] and Walker and Scott-Melnyk [6] have performed factor analyses on museum visitor surveys, where several important factors influencing visitor behaviour are found. They extract the following factors: Easiness and fun, cultural entertainment, personal identification, historical reminiscences, and escapism, learn about cultural heritage, support organizations, learn about another time or culture, learn more about a particular form of art, experience high quality of art, support a friend or family member involved, attend a religious service, and get together with friends of family.

Hood's [3] study derives several factors by looking not a museum visiting in particular, but by looking at factors influencing leisure time spending in general. According to this study, individuals 'do not just naturally gravitate to museums or to any other leisure place' but instead

'they consider several competing alternatives'. Therefore all factors influencing leisure time spending should be investigated, not just museum specific ones. This study finds the following six factors influencing leisure time spending: Social interaction, doing something worthwhile, feeling comfortable and at ease in one's surroundings, having a challenge of new experiences, having an opportunity to learn, and participating actively.

Morris et al. [5] look at visitor behaviour on a higher, hierarchical level. They use a similar approach to the one found in [4], but the decision was made to group factors on a higher level. They find the following four factors: Social, Intellectual, Emotional, and Spiritual. This study also suggests that these factors should be seen as a hierarchy, where the visit becomes more fulfilling if one goes higher up the hierarchy, but this can only happen if the needs of the factors below are met.

All the overlapping elements found in the studies have been grouped together to create a more coherent list. Most of the studies find similar factors, so what is left is a list consisting of only nine visitor motivations that describe all the factors in the studies above. These visitor motivations will be described in the paragraphs below.

Explorers are visitors who go to a museum out of curiosity, they want to learn, be culturally entertained, and are interested in learning something about another time or culture. This visitor group is a combination of the explorer, opportunity to learn, intellectual, cultural entertainment, and learn something about another time and culture group.

Professionals are visitors who have pre-existing knowledge of the things on show at the museum. They want to be able to learn at their own challenging level, and identify with the available exhibits. This visitor group was derived from the professionals, having a challenge, personal identification, opportunity to learn, intellectual, and wanted to learn more about a particular form of art groups.

Experience seekers are visitors whose main motivation is to have a good time, they are mostly motivated by their emotions. They want to have a good time, and be at ease in their surroundings. This group was based on the experience seekers, easiness and fun, emotional, and feeling comfortable variables.

Rechargers are visitors who are spiritually motivated, they see going to a museum as an opportunity to recharge and escape. This group also includes visitors who visit for religious reasons. Combining the rechargers, spiritual, escapism, attend or participate in a religious service factors creates this visitor group.

Facilitators are visitors who want to enable their accompanying group, or the organization involved. They want social interaction, and to get together with friends and family. This group is built up out of the facilitators, social interaction, social, to get together with friends or family, and support organization and friends groups.

There are four more well-defined visitor groups that require less explanation, these will be discussed in this paragraph. These groups are: "visitors who want to do something worthwhile", this is more than just being intellectually challenged. "Visitors who want to actively participate", for whom the possibility for interaction is a main motivator. "Visitors who are motivated by historical reminisces", who want to reminisce about the past and learn about or celebrate cultural heritage, and "Visitors who want to visit for the high quality of art", who are less affected by the other factors in a museum, but only want to be able to enjoy the art.

2.2 WHAT FACTORS INFLUENCE WHETHER A TARGET GROUP VISITS OR NOT?

Now that the different types of visitor groups have been established, it is important to know what determines whether they actually visit or not. How to draw more visitors to a museum is the first topic that will be discussed. After this, other factors that influence visiting, and the relative importance of motivations will be discussed.

In order to draw more visitors to a museum, an individual needs to see the museum as a place where their needs can be fulfilled. Falk [2] suggests that if a visitor's expectations are met, and if they think that a museum can satisfy their needs, they would be more inclined to visit again and tell others about the museum. This could make non-visitors into occasional visitors, and occasional visitors into frequent visitors.

Motivation and the fulfilment of personal needs is not the only factor in participation choices. Walker and Scott-Melnyk [6] have created a conceptual model for individual participation choices. This model suggests that individual resources and community factors also play a role in how people participate. If a non-visitor does not have the resources or the paths of engagement and structure of opportunity, they will not become a visitor, regardless of their personal motivation. Changing an individual's resources or paths of engagement, however, are not the main focuses of this literature review; so from here on the assumption will be made that motivations are the only factor that can be influenced.

Based on the numerical values from the previous studies, a calculation can be made and the relative importance of the visitor groups can be derived. Many of the studies done have calculated importance of individual factors. They have looked at which factors are valued most by visitors or which percentage of visitors consider a certain factor to be their prime reason for visiting. By combining the found values of these studies for similar and overlapping factors new individual factor weights can be calculated.

<i>Visitor motivation</i>	<i>Relative importance</i>
Facilitators	46,00
Explorers	44,92
Professionals	42,28
Experience high quality of art	42,00
Experience seekers	37,46
Rechargers	35,60
Historical reminiscences	32,17
Doing something worthwhile	-
Participating actively	-

For two motivations, a numerical value could not be assigned – the underlying values of the original studies were not published. The relative importance of factors found in the table lines up with the hierarchy of [5], social factors provide the most opportunity for improvement in museums, followed by intellectual reasons, emotional reasons and spiritual.

Hood's [3] research shows that non-visitors and frequent visitors value attributes differently from one another. The frequent visitors value all the motivations Hood presents, but 'having an opportunity to learn, having a challenge of new experiences, and doing something worthwhile' most. However, Sheng and Cheng's [4] analysis suggests frequent visitors highly expect elements of easiness and fun, while this is not included in Hood's [3] main three factors. The non-participants value the exact opposite attributes most; social interaction, participating

actively and feeling comfortable and at ease in their surroundings, and the other three reasons relatively little.

While motivations are not the only factor influencing whether individuals visit, it is the only factor that can be easily influenced by product design. For product design in museums to be most effective for most visitor groups, the needs of the social and intellectually motivated groups (Facilitators, explorers, professionals) must be met.

2.3 WHAT ARE CONCORDIA'S NEEDS AND DESIRES?

Naturally, visitors have their own desires and motivations, but in this project we also need to fulfil Concordia's needs. Therefore, this chapter will focus on what they want, and think they need to achieve this. There is usually a difference in what someone thinks they need, and what they actually need, so Concordia's visitors will also be interviewed to see if there is a significant difference between the two.

THEIR VISION

This subchapter will discuss what Concordia's desires and vision are. Concordia believes that art is for everyone, and that "Everyone should be able to experience art, both consciously or subconsciously". Based on this, a main requirement for the developed project is that it makes art interesting for a wide variety of target groups. This would mean that Concordia wants to satisfy as many user needs as is possible.

THEIR EXPECTATIONS

Concordia thinks that most of their current visitors feel like they need more context for art. According to them, many visitors have an enjoyable experience, and are entertained by the art, but they are also confused by 'what it means?' and 'why it is relevant? '. This suggests that visitors struggle with learning.

If Concordia's assumptions are correct, the visitor groups who value learning should not find their museum fulfilling, and should be under represented in their visitors.

THEIR VISITORS

To see if Concordia's expectations are correct a survey will be conducted. The goal of this survey is to find out if Concordia's expectations are actually somewhat representative of their real visitors. The researches referred to in the literature review have performed similar surveys, such as that of Sheng and Chen [4]. In these surveys, factor analysis was done on a large set of user replies to questions regarding general visitor behaviour. In this survey, the visitors were only asked which of the nine visitor groups describes them. For every visitor group, the visitor can select how much they agree that the visitor group is representative of their own visitor patterns; strongly disagree, disagree, neutral, agree, or strongly agree. The approach used here features fewer general questions as the surveys from the literature review, and is not as thorough as the approaches used in the previous studies. The choice was made to use this

simple survey nonetheless. Considering the lower amount of replies our survey is likely to receive, and the simpler goal of the survey – our simpler survey can still reasonably be used within this project scope.

The visitors were asked to answer the following nine short questions, which correspond to the previously established visitor groups.

1. High quality of art - I visit for the high quality of the art
2. Do something worthwhile - I visit so as to do something worthwhile
3. Explorers - I visit to explore and discover new things
4. Facilitators - I visit for social interaction, to do something with family and friends or to support others
5. Professionals - I visit to learn more about a hobby or profession.
6. Experience Seekers - I visit for the experience, mainly to just have a good time
7. Rechargers - I visit to relax, to escape everyday life.
8. Participating Actively - I visit to participate actively.
9. Historical Reminiscences - I visit for historical reminiscences

Visitors were asked to answer these questions during opening hours of exhibitions (as this was one of the few possible scenarios where multiple visitors were available for polling). Not disturbing the visitors during their visit was a very high priority requirement, so only visitors who were not obviously engaged by art or other people could be asked to participate. Due to this, only fourteen samples could be collected, however some very cautious conclusions could possibly be drawn nonetheless.

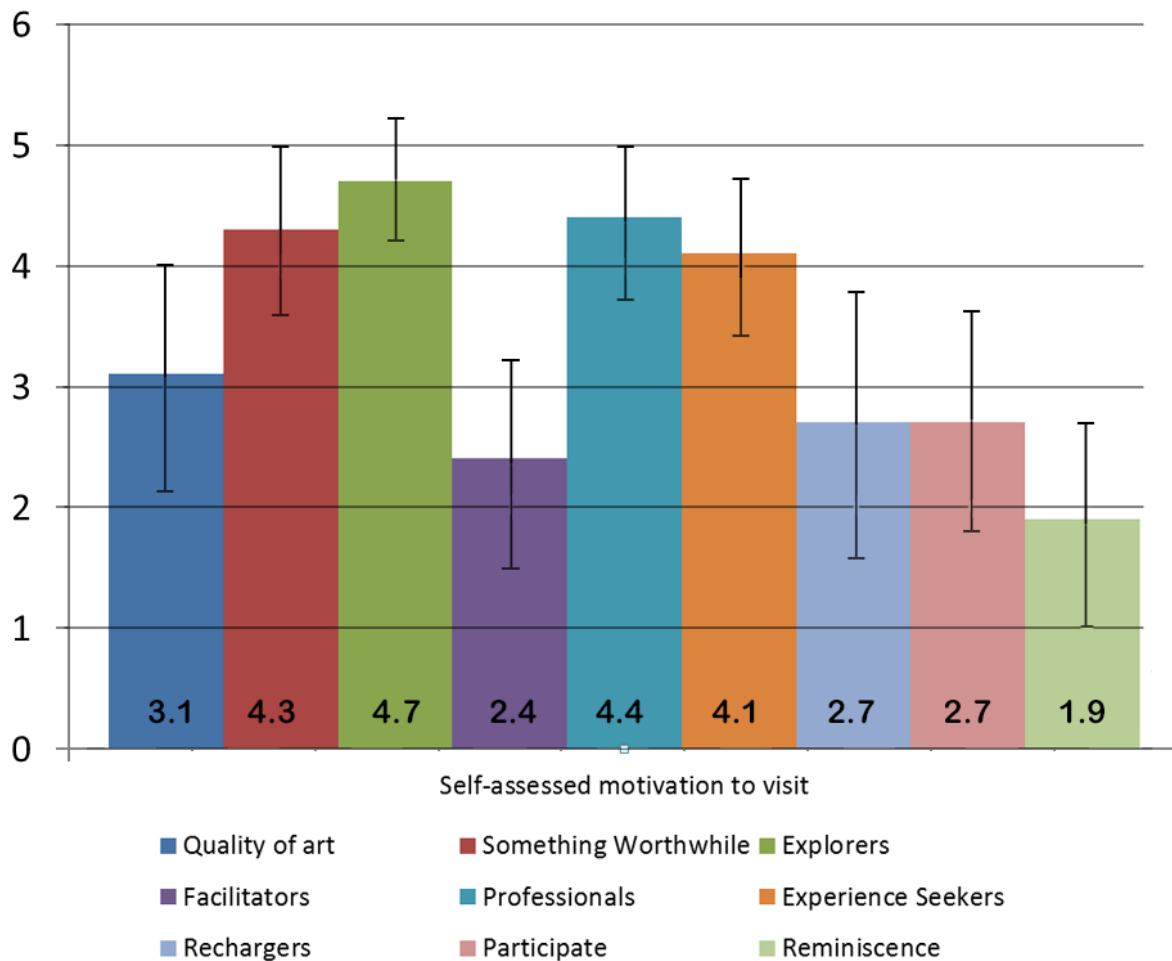


FIGURE 1: BARCHART OF CONCORDIA'S VISITOR MOTIVATIONS

The survey's results and their standard deviations are shown above. Concordia's current visitors seem to value historical reminiscences and learning about or celebrating cultural heritage relatively little. This is slightly unsurprising, as Concordia usually does not have historical exhibits or cultural heritage related items. Therefore, while this factor has received a very low score from the current visitors, we will not put extra emphasis on the respective design guidelines.

Concordia also seems to have a pretty solid visitorbase of happy explorers and professionals, most seem to think that going to Concordia gives them a feeling of doing something worthwhile. This suggest that Concordia already has an excellent way of making their visitor experience enjoyable for the groups that value learning, and one could suggest that therefore their expectations that visitors need more context for art could be wrong.

The facilitator, recharger and participation groups seem somewhat relatively underrepresented. These are the areas where Concordia's visitor experience could be improved most. In order to improve the experience for these groups their design guidelines should be prioritised.

2.4 WHAT ARE THE POSSIBILITIES OF IBEACONS?

To explore the technical possibilities of iBeacons and applications for museums, an analysis of existing applications was performed. This analysis was done by looking for patterns in several iBeacon reports of uses, as well as websites of iBeacon users. The uses will then be sorted into four different categories: iBeacons at other museums, non-beacon museum apps, iBeacons in Retail, and other applications' frequent features. The complete overview of references and systems used can be found in appendix A.

iBeacons at other museums

Here's a list of features that are found in most museum iBeacon applications.

- Location tracking, usually combined with information about the art you're close to.
- Interactive apps
- Improved learning by providing new media, video and audio.
- More information about art. Using apps, museums are able to provide more and different kinds of information.
- Sharing on social media. Gives users the opportunity to share a photo or information in the app on Facebook, twitter, etc.
- Find all the beacons games, get rewarded with in-app achievements if you find them.
- Interactive games related to exhibits, where players can play with or against their accompanying group.

Non – beacon museum apps

Most non-beacon apps have similar features to the iBeacon museum apps. The only real difference is that non-beacon apps do not have access to the same high-accuracy location tracking. These are some features that were found in these non-beacon apps, that could also be used in iBeacon apps:

- Different length tours so even the visitors who have limited time can have an enjoyable experience
- Calendar of upcoming events and exhibitions in the museum

iBeacons in Retail

The museum context is not the most common context in which iBeacons are used. Most applications are aimed at retail. While this is a very different scene, features used in retail applications could still prove useful in museums too.

- Tracks what product you are standing in front of, and tells you what you could trade in your old model for.
- Big data showing you offers for similar products to the one you're standing next to.
- Coupons on phone
- Directions to products
- Customer loyalty cards. Discounts if a visitor has visited before
- Reviews of products on phone
- Request service from clerk

Others

- Notifications of possible seat upgrades when you get in event range.
- Heathrow airport: Display customer's boarding pass when they go to the gate

While this gives a good overview of potential uses for iBeacons, there are some aspects that were not included in this overview. Some beacons have extra sensors, such as temperature and light levels. iBeacons are relatively simple, technology-wise, and equipping them with sensors makes them a lot more advanced. Despite this big difference and available technology, no examples of applications that use this technology can be found. This leaves a lot of opportunity for research and innovative applications.

2.5 HOW CAN THESE FACTORS BE USED IN PRODUCT DESIGN?

Every visitor motivation has its own needs, now that a relative motivation importance has been deduced, a way of using the needs of these groups to create a more successful product must be found. In this chapter, the “doing something worthwhile”, and “wanted to visit for the high quality of the art” visitor groups will not be discussed, as the amount of literature found on these topic was insufficient.

Facilitators

Using tangible user interfaces, and accessible description design frees up mental space in visitors, allowing for more social interaction. When using tangible user interfaces, the user threshold for an activity is lowered – the user has to focus less on interacting with the device. This gives visitors an opportunity to refocus their attention to social interaction. [7] In combination with a low activity threshold, visitors should also be able to quickly refocus their attention between their companions, the location, and the informative product. [8] This can be done by providing a way for visitors to share descriptions of objects, providing short descriptions of objects, supporting audio presentation of descriptions, providing random access to information about objects, allowing visitors to have an unshared product, and providing a method of selecting objects visually.

Explorers

Strong feelings of curiosity can be inspired in visitors by letting them feel deprived of information. Litman [9] says curiosity can be aroused when people feel deprived of information, or when they do not necessarily feel deprived, but would like to learn something new. The deprivation feeling is linked to a needing state, whereas the interest feeling is more often associated with casual and entertaining state. Because of the difference in importance of the information need, it is assumed that the deprivation corresponds to a more intense feeling of curiosity, which motivates more exploration.

Another way of introducing curiosity in visitors, is by confronting visitors with states of uncertainty and conflict. Arnove [10] suggests that adding elements of incongruity, contradictions, novelty, surprise, complexity, and uncertainty induces curiosity. Introducing thought provoking questions or surprising statements could also hook individuals. Berlyne [11] supports this statement, suggesting that curiosity is induced by complex situations, incongruity, doubt, and difficulty.

However, with all these elements, it is important to find balance the amounts of curiosity feeling introduced. Day [12] suggests that if an individual feels over-stimulated, they can move from the “zone of curiosity” into the “zone of anxiety”.

Professionals

In order to fulfil the professional’s needs a fun learning environment needs to be developed, where they can learn at their own level and pace. To facilitate their learning a successful learning experience needs to be set up. Combined with the providing the right, complex, information for these learners’ needs, Lin and Gregor’s [13] study mentions that successful

learning in museum initiatives requires making learning fun. This can be done through interesting content, encouragement, and engaging experiences. Furthermore, learning can be stimulated by allowing the learner to learn at their own pace, using audio and visual multimedia technologies representing real world scenarios.

Experience seekers

When designing interfaces for fun, there are several features that can make the experience more enjoyable for users. According to Shneiderman [14], fun features in interface design are alluring metaphors, compelling content, attractive graphics, appealing animations, and satisfying sounds.

The physical factors that influence whether an environment is comfortable or not, must not be influenced for the worse by the designed product. In order to ensure visitors feel comfortable buildings must have correct air quality, and thermal conditions, and other similar physical factors [15]. Most museums already have a way of regulating their indoor climate, and replacing this function is not a goal for most products in a museum context. However, it must be taken into account, so products will accidentally upset the museum's climate control.

Visitors can only enjoy the visitor experience, if they can locate themselves in terms of time and space, and feel at ease in their surroundings. Goulding [16] suggests giving a visitor a map of the museum can greatly increase visitor satisfaction and comfort. This map needs images of key exhibits, and should be reinforced with physical signs in the museum.

Rechargers

The needs of the rechargers are similar to the experience seekers' needs, and can only be fulfilled once the experience seekers' needs are fulfilled. Kaplan et al. [17] say restorative experiences are far less accessible to the non-visitor group. Problems in orientation and way finding and lack of feeling comfortable undermine the experience for non-visitors. They suggest that if a visitor does not feel comfortable, they can not enjoy the restorative experience. [5] supports this statement – spirituality is the top layer of the hierarchy, and can not be achieved without the underlying layers. The layer directly under the spiritual layer, is the emotional, experience seeker layer – in order to design for the rechargers we first need to design for the experience seekers. Therefore, the recharger motivation will not be taken into account in this review's design guidelines.

Visitors who are historically motivated.

The factors needed for reminiscence contradict the needs of more prominent groups, and will therefore not be included in design guidelines. Bryant et al. [18] suggest that reminiscence occurs most often in cases where individuals feel negative emotions. To induce reminiscence in visitors, negative emotions could be used, however, these negative emotions directly contradict the desires of the experience seekers. As the importance of historical reminiscences scores quite low compared to the importance of the experience seeker group, it is inadvisable to induce sad feelings in visitors solely for this purpose.

The learning aspect of this group's needs is already represented by the design guideline for professionals, and will therefore not be included again in this user group. In order to facilitate these visitor's learning about cultural heritage, a successful learning requirement has to be created. The design requirements for this have already been discussed in the chapter on "professionals". The only element that needs to be adapted here, is the information provided.

Visitors who want to actively participate.

When designing for active participation, visitors must be allowed to shape the visitor experience of others, and fully understand the interaction products available. According to Von

Lehn [19] the most important factors when designing for interaction in museums are enabling visitors to change and shape the visitor experience of others. Furthermore, allowing visitors to participate privately, or to give them the means to understand products made for multiplayer interaction also facilitates interaction. This study also suggests that the designer always needs to acknowledge the fact that social interaction affects how people experience an exhibit; the presence of strangers or companions changes how individuals interact with a product.

2.6 CONCLUSION

At the start of this chapter, the following research question was posed: 'What are the design guidelines when trying to increase interest in museums?'. By looking at who visits museums, what factors influence this and how this can be used in design, a list of design guidelines was created. Implementing these guidelines in product design, could make museum visits more enjoyable, and possibly increase interest in museums. However, scientific information could not be found for all the visitor groups, therefore these could not be included in the design guidelines. Another factor that was not taken into account in this study, are the visitors who aren't visiting because of their personal motivation, such as school excursions. Their motivations, or lack thereof, are not included in this research.

Concordia's expectations that their visitors 'need more context for art' will not be taken into account. The visitor survey conducted in this research actually shows that most of Concordia's visitors visit for learning reasons, suggesting that visitors do not struggle with context or understanding.

When looking at similar systems, there are many interesting applications to be found. Many of these systems use similar features, however, there seem to be very little applications that the extra sensors that some iBeacons have. This is an excellent opportunity for further research and innovative developments.

While the research question has been answered, there are still recommendations for further research. More research should be done so an insight can be gained in how to design for the "worthwhile" and "high quality of art" visitor groups. Although all the other visitor groups have their own design guidelines, these too, could benefit from further research, so even more guidelines can be developed for these groups. The design guidelines could also benefit from testing and actual application, so real visitors can give feedback on what works for them and what doesn't.

3. IDEATION

The state of the art chapters have given several design guidelines and ideas for possible iBeacon solutions. Using this information ideation is started, and this process is described in the following chapters

As a start of the ideation process, brainstorming was done, which over the course of many days resulted in many different concepts. While brainstorming the possibilities and limitations of iBeacon technology were kept in mind. My supervisor had also kindly asked some of his students to come up with iBeacon concepts for different categories. These categories were iBeacon apps that enhance storytelling, learning, logistics, social interaction, and inspiration. After having removed the duplicates from the students' set of concepts and removing the concepts that were already included in my personal list, ten student concepts were left. Combining these concepts with my own created a large list of forty-five different concepts.

To determine which concepts are good enough to be included in this list, several factors of all the forty-five concepts were rated on a scale from one to five. These factors were their feasibility, how much fun they would be to make, how enjoyable they would be for my nine visitor types, and how much they would improve storytelling, learning, social interaction, logistics, and visitor inspiration. An average of these nineteen factors was then calculated to roughly determine how good the concepts were. The full list of concepts and factors is in appendix B. According to this, the virtual reality atmosphere, self-guided tour, idea sharing/discussion space, artists vision/work in progress, and interactive quiz were the best concepts.

These five concepts will now be described in more detail.

- Virtual reality atmosphere
 - A multi-sensory experience, where using a visitor's location, a system projects ambient footage, and plays sound that subtly suits the museum's exhibitions.
- Self-guided tour.
 - A general phone app that lets the user learn and explore the art at their own pace. This concept can be combined with giving the visitor an opportunity to virtually zoom on paintings, showing them a calendar of upcoming events, and letting visitors select several different tours.
- Idea sharing/discussion space
 - A system centred around giving visitors an option to share ideas and discuss art. The main goal of this concept is to improve learning and improve social interaction in the museum.
- Artists vision/work in progress
 - A new take on the generic touring systems. Instead of giving visitors factual information about the exhibits, the visitors gain an insight in the artist's vision. To further improve understanding of the artist's process work in progress images could be included.
- Interactive quiz
 - This concept helps visitors learn by giving them interactive quiz games that they can play through by themselves or with other visitors. The visitors get questions about the art on display to see how much they understood/remembered. Visitors can then compete to get onto the high score board.

These five remaining concepts were then explained to two of Concordia's people to determine how much they approved of the concepts. They were both asked to rate the remaining five ideas on a scale of one to five. After this selection process, two concepts were left. These concepts will be discussed in more detail.

3.1 SELF GUIDED TOUR

3.1.1 BASIC CONCEPT

A tour app that allows users to explore the museum at their own pace. The landing screen of this app lets the user select which language they would like to use the app in, and how much time they wish to spend in the museum. The language selection options will make the app more accessible for people with different nationalities, which will be very useful considering how close Concordia is to the German border. They personally see a lot of demand for German information in their museum.

Since the museum is located in the city centre, a lot of people pass by every day. However, not everyone has the time to visit or the desire to spend a long time at the museum. By allowing the users to select a desired visiting time on the landing page, we give everyone the opportunity to visit however they would like to. Three different length options will be offered, one where the user only gets to see the highlights (5 minutes, excellent for during a short lunch break etc.), one where he gets a standard amount of information and gets to see all the pieces on display (15 minutes, the average tour), and one tour intended for people who want to receive as much information as possible (30 minutes, extra in depth info for professionals and hobbyists). If the user decides that they wish to spend more time in the museum after all, or that they want more information about a specific piece, the app will allow them to do so. It would be nice if a user can change their desired tour length without encountering repetitive information.

After the landing page, the user will get to see an overview (map) of the museum where the pieces they will receive information about are shown. They can click on a piece to receive information about it, but they can also simply walk into the piece's iBeacon signal range. This makes the app usable for newer smartphones with BLE support, as well as older models that lack this technology. The overview map will also help users orientate and feel more comfortable, which will stimulate the experience seekers and the rechargers. The unexpected, surprising element of the information suddenly appearing on screen when you get in range of a beacon could be the curiosity element



FIGURE 2: PROTOTYPE OF SELF GUIDED TOUR ART PAGE

that the explorers want.

The information can be presented in various ways. The app should definitely have text based information, as this is the most easily accessible way of presenting information (see right). Next to this, the user should be able to choose an audio tour instead. The user can select audio tracks manually, but also let themselves be informed about the things they are walking past/standing next to. This natural progression through information using beacons should make the app very



FIGURE 3: PROTOTYPE OF SELF GUIDED TOUR EVENTS

user-friendly, even for the more tech-unaware visitors. To make the transition from one beacon to the next smooth and to prevent audio cutting off mid-sentence, a notification can be sent to the visitor, telling them that they are leaving the beacon range. This could be done with a visual push notification or perhaps with an audio based signal.

To keep the user informed about upcoming events in the museum they will be able to navigate to an events panel where they will see Concordia's upcoming events. Clicking on an event will send them to a screen that is similar to the art piece information screens, with an event date a photo/video, and extra information about the event. This could potentially be combined with tracking how much time a user spends looking at a piece. If a visitor spends several minutes near a certain piece of art, then we could recommend them a similar upcoming exhibition using a subtle notification. To do this, the app would need to be able to send information (like phone system time, with a tag) to a server. This information could then also be used to estimate what content a user is interested in, and what exhibitions should be made to attract more visitors.

When the data is available, it would also be interesting to provide all kinds of new media information. For example, instead of displaying a photo, a navigable 3D render of the piece could be used, or a video. The app also allows for all kinds of new interaction that would not be possible otherwise. For example, if a high resolution photo of the art is available, the visitor can zoom in on the art to see more detail. This would especially be interesting for the professionals and hobbyists.

Concordia likes this concept, they think it is versatile enough to be used for multiple exhibitions, and they are confident that they should be able to adapt the content in the app themselves. They also see this app as a great base to build lots of other interesting features on.

3.1.2 POSSIBLE IMPROVEMENTS TO THE SELF-GUIDED TOUR

In its current shape, this concept has limited social features, thus making it less appealing for the facilitators and socially motivated groups. The social aspect of this application could be enhanced by letting users share their thoughts and opinions on the art pieces with other visitors.

The concept could also benefit from some more interaction, to make it more interesting to the “actively participating” audience. Adding some way of having physical feedback on what the user is doing, or how he is moving around in the room would be fun, but this does make the visitors focus less on the art.

3.2 ARTISTS VISION/WORK IN PROGRESS'

3.2.1 BASIC CONCEPT

Sometimes it is unclear for the visitor what a piece of art means, is, and what it is trying to tell you. While this is very subjective, it can be interesting to see how the artist feels – there might even be an interesting contrast between what the visitor feels and what the artist intended. This lines up with what Concordia thinks their visitors need; more context for art.

This context would be less factual and textual than the information presented in the 'tour guide' concept. However, users might find the story behind the art, why it was made, and how it was made far more interesting. It would be a nice eye catcher to be able to present time lapses of the art in progress to users. This is a more innovative way of presenting information in a museum. Instead of just giving the factual information and improving learning, the main goal here is to make the visitor passionate about art and to increase more understanding regarding the process of making art.

This way of giving information could also be a lot more accessible for various visitor groups. Some might not be interested in the art itself, but they can still be interested in the story line around it. Like what the artist's reason for making this was, some fun behind the scenes facts etc. To further increase enjoyment for facilitators, a way of letting visitors access random information about the objects should be considered.



FIGURE 4 PROTOTYPE OF ARTIST'S VISION APP

If the artist is willing to share extra information about the art piece, this information could also be presented in a more lecture-based way. A video where the artist explains more about a specific aspect or challenge of a painting could be enhanced by letting the artist 'draw on top' of the art (see right). This could create a more learning-heavy art experience that might be very appealing to the professionals/hobbyists.

To support the visitors who would rather not walk around, constantly reading text on their phone, audio options should be available. To enhance the feeling of immersion into the artist's world, these audio clips should follow a nice storytelling line. To increase the enjoyment for the explorers, the storyline should have several curiosity inducing moments (e.g., interesting questions, information deprivation etc.)

For this app, we will also need a kind of overview page, indicating where the beacons and art pieces are (this matches the needs of the experience seekers). Visitors should then be able to select pieces and navigate to their respective artist pages by clicking on them. To meet the experience seekers and the rechargers' requirements this could be done with a map.

3.2.2 POSSIBLE IMPROVEMENTS TO ARTISTS VISION/WORK IN PROGRESS'

The social, learning, and participation aspects could benefit from some more support in this concept. This concept currently has no social element. It could however be interesting to let visitors share how they interpret/feel about art pieces in the app. This information could then be collected and analysed and presented to all visitors to further display the contrast between the visitors' and the artist's interpretation.

While the app does have a learning aspect, it is more focused on giving visitors a feeling and an understanding of artistry. The actual factual learning is less present in this concept than in the other self-guided tour concept.

The concept currently has no participation aspect, which makes it less interesting for the visitor groups who are interested in this. This could potentially be fixed by creating opportunities for visitors to activate sounds, voice guides, or videos on screens in the museum. This would give the same information as is available in the app, but it gives the visitor the opportunity to shape the experience of others too. This solution does however, bring along some difficulties. Certain visitors might for example, not like the way their experience is being shaped by other visitors.

Another potential issue with this concept is that if the data needed for the app isn't available, the entire thing will not work. If for example, an artist does not wish to share their work in progress or give information about the process, we will have nothing to display.

3.3 FINAL CONCEPT SELECTION

After supervisor feedback, both of the concepts were found to have enough depth for a CreaTe graduation project. Concordia too, agreed with both of the concepts and they were equally excited about both of them.

Artist's vision		Self-guided tour	
Pros:	Cons	Pros:	Cons:
Interesting take on information about art	Relies on artist participation	Possibilities for more features	Not too innovative
More innovative	Users might not be interested in the artist's take on things, desiring more factual information	Easier collection of content in the app	Multiple tours means lots of content which needs updating.

After analysing the pros and cons of both the concepts, the decision was made that the self-guided tour app would be the safest concept to use. The main reason for this final selection is the fact that the self-guided tour app is more broad, and it gives me many opportunities to develop more features in the future. Another reason is the ease of data collection. Like stated before, if the artist does not wish to cooperate or does not have time to do this, the app will have no information and be practically useless.

4. SPECIFICATION

APPROACH

Now that a concept has been chosen, the concept must be further defined to facilitate more efficient realisation. This specification process will be done by creating user scenarios, which will give a better insight in the experience the concept should create. Early prototypes will be created and discussed to gain an insight in the do's and don'ts of realisation, as well as exploring efficient methods and possibilities for creations.

In addition to these techniques, personas-based design [20] was used to possibly improve the user experience for unusual user groups. These personas were often referenced during the design process to see how design choices would affect these users. The distinctive factors of these personas are visitor motivations, affinity for museums, and visitor group size. The full personas can be found in appendix C.

Based on the experience specification, earlier brainstorm, the literature review, and the early prototype a functional specification was created. This functional specification will be used as a leading guideline for the realisation process.

While the specification has been written down rather linearly to improve readability, it is an iterative process. The information gained from the experience specification, also changes how an early prototype is developed.

4.1 EXPERIENCE SPECIFICATION

To get a better idea of what experience this app should give its users, two user scenarios are written down here. By mentally experiencing these scenarios errors in the current design or more recommendations can be found before prototyping begins.

Use scenarios

Mother and son

A mother and son are out having lunch in the city centre. As they walk past Concordia they see an advertisement for Concordia's five minute museum tours. After having had lunch, they decide to stop by Concordia for a five minute tour, after all, it's only five minutes long and it might just be an interesting diversion.

Once they are inside the museum, the receptionist refers them to the app. Once the mother has downloaded the app on their phone and selected the five minute tour option on the app, they see the map overview on the phone. This map overview only has two circles on it, it is only a five minute tour after all. The mother already had her location and Bluetooth turned on before entering the museum, so when the map opens they will see larger circles for the art pieces that are close to them. Because these circles are changing in size, they are inviting enough to make one of the two press the circle.

Once one of them has pressed the circle, information shows up on the screen. The son is not too interested in reading the text on the screen, so he decides to only read the short interesting description on the top of the screen. The mother would like to listen to the audio information about the tour, so she can still interact with her son while receiving information.

Once the audio tour stops, they go back to the map overview. The son scrolls around on the map to find the next circle, once it's found they move on to the next and last piece of their short tour. The mother decides that she wishes to listen to the audio information for this piece too, so they can both receive information at the same time without having to do a lot of reading.'

Regular Concordia visitor

An elderly lady has been visiting Concordia for years, she's a real art lover and visits whenever Concordia has a new exhibition. When she heard about the new app available in the museum, she wasn't immediately enthused. However, when she came to the museum for Concordia's next new exhibit and saw the posters promoting the app in combination with the new exhibit, she was convinced to try it.

Once she's downloaded the app at the entrance to the museum, she sees the popups recommending that Bluetooth and location permissions should be turned on. She however, has little to no experience with android and doesn't know how to turn on these permissions. She reads that the app works without these permissions too, so she doesn't bother to switch them on. Once she's arrived at the next screen, she selects the thirty minute tour.

Since she's not the most interface aware user, she needs a tutorial on how to interact with the interface. It's also important for her to have larger clickable icons, as her fingers tend to tremble. She also has a need for large text – her vision isn't what it used to be.

After reading the short tutorial she somewhat understands what she can do with the interface. After some trying around on the map activity she understands that she can click on the circles to receive information about the art. However, she would rather not have to think about all the elements of the app, she'd rather have the same, easy experience she always had when visiting the museum. The receptionist suggests she turns on autotour instead, so she can focus more on the museum and spend less time with the app.

Once she's changed her Bluetooth and location permissions and turned feature on she is very pleased with the visitor experience as a whole. She can ignore the app where she wants to, and have the exact same experience she's always enjoying in the past – or look at the app when she wants to receive a little more information.

4.2 EARLY PROTOTYPES

During the early prototyping phase, the decision was made to create the app for android. If one is creating an app, it's very important that you are able to test it on your own phone constantly. Since during the development process, an android device was the only one that was easily available, making the app work for android was an easy decision. In the future, it would be advisable to make the application suitable for multiple operating systems, however, this does not fall within the scope of this project.

The earliest prototype of this application was a beacon reference application [21] made by David G. Yough. The decision was made to use David G. Young's android beacon library, so starting by downloading and looking at the corresponding reference application seemed a logical step.

The first page of this app's layout was removed, and replaced with a new xml layout, this was to become a brand new landing page. Then, some new art information pages were added and the Ranging activity was adapted to let it automatically switch to some predefined art information pages if you got close enough. A primitive auto tour was born!

However, with this approach, the application lacked a clear overview. While the automatic switching of activities was fun, it was hard to get an estimate of how big the app really was and what you could do in it. If you didn't get close enough to the physical object the activity refers to you will never get to see it and you will never know it is there.

4.3 FUNCTIONAL SPECIFICATION

To further define the exact requirements and specifications of the concept, all the guidelines and requirements collected at this point will be sorted into categories. These guidelines and requirements will then also be rated by priority in this project, 5 being very important, and one being very unimportant. Combining the innovative elements from brainstorming with the guidelines from literature review in a list of requirements and recommendations should give a higher likelihood of creating a successful project.

The points mentioned in this list will not be discussed or explained in much detail, as most come directly from either the project description or the literature review. However, some details and explanations will be given for the elements that were discarded at this stage.

PROJECT DESCRIPTION REQUIREMENTS:

- Use of iBeacons 5
- Adaptability 4

USABILITY FACTORS:

- Adaptability 4
- Text based information 5
- Multilanguage support 3
- Support for older, non BLE phones 2
- Not having great impact on the museum's climate regulation 4

USER-FRIENDLINESS FACTORS:

- Clear navigation for users 4
- Audio tour options 3
- Allowing visitors to interact and participate privately 2
- Allow visitors to have an unshared product 2
- Audio alert when a user is leaving the range of the audio tour playback 4
- Changing information if user changes tour length 1
- Support for people who don't want to turn on Bluetooth or location permission 2
- Completion bar 1
- Support audio presentation of descriptions 3

USER-ENJOYMENT FACTORS:

- Providing a method of selecting objects visually 3
- Giving a visitor a map of the museum 4
- Different tour lengths 4
- Support for new media to make the app more innovative. 3
- Alluring metaphors, compelling content. 5
- Attractive graphics, appealing animations, satisfying sounds in interface design 4
- Adding some way of having physical feedback on what the user is doing 3

SOCIAL FACTORS:

- Providing a way for visitors to share descriptions of objects 2
- Provide short descriptions of objects 4
- Tangible user interfaces 1
- Giving visitors the means to understand multi-user interactive devices 4
- Letting users share their thoughts and opinions on the art with other visitors. 2
- Provide random access to information about objects 4
- Enabling visitors to change and shape the visitor experience of others 4

LEARNING FACTORS:

- Letting learners learn at their own pace 4
- Audio, visuals, and interactive multimedia presenting real world scenarios 3

CONTENT FACTORS:

- Information deprivation, feeling of interest 4
- Uncertainty or conflict arousing states 3
- A right balance in curiosity states 5
- The right difficulty level in information provided 5
- Encouragement, interesting content, enjoyable experiences 4

FACTORS THAT BENEFIT CONCORDIA:

- Information about exhibits 5
- Information about upcoming events 4
- User tracking, featuring personalized content in the app. 2
- Options to invite visitors up the stairs 3

DISCARDED ELEMENTS:

- Tangible user interfaces - While tangible user interfaces present many interesting design opportunities, it is less suitable for this specific project. Adaptability is very important for Concordia, and the technical complexities of a tangible user interface make adaptability less feasible. They would also like an app that offers many opportunities for including further features, this is also more difficult to achieve with tangible user interfaces.
- Giving visitors the means to understand multi-user interactive devices – The app does not use multi-user interactive devices, therefore this factor is not relevant to this particular project
- Enabling visitors to change and shape the visitor experience of others – Concordia feels that this particular element could be too distracting for many visitors, which would negatively influence their user experience and their actual enjoyment of the art.
- Adding some way of having physical feedback on what the user is doing, or how he is moving around in the room – While Concordia liked this idea, they did not think it would be suitable for all exhibitions and could be too distracting in certain cases. Concordia want to facilitate visitors in being able to fully enjoy art first and foremost. This also requires a lot of technological knowledge to create and maintain, so it does not meet one of their main requirements; adaptability.

4.4 CONCEPT DESIGN

Combining this list and the chosen concept leads us to a specification of concept design. This specification was done by thinking of possible efficient ways of integrating the features in the list above in an application screen. Sorting the desired features at this stage also has the added benefit of 'decomposing' the whole into smaller, easier parts. This should make realising the components a lot easier.

First, the more general elements such as navigation, adaptability, and use of iBeacons are explained. Afterwards, the specific screens and elements of the application will be discussed.

4.4.1 GENERAL ELEMENTS

General

Attractive graphics, appealing animations, and satisfying sounds in interface design - Not have great impact on the museum's climate regulation - Unshared product - Allowing users to interact and participate privately.

These are all app wide features that can be applied to all activities in the app. Attractive graphics can be used everywhere to make the app better. Appealing animations could be used to make elements stand out more, and satisfying sounds could be used to clarify the usability of elements or to make the app more fun.

As for the museum's climate regulation, this app will not affect it in any way. Therefore the app will have no effect on how the visitors experience the comfort of the museum in this way.

Because the app will be used on a phone platform, most users will have access to an unshared product, and will have the opportunity to interact and participate privately. This ticks two more 'should have' boxes.

Use of iBeacons

Use of iBeacons - Clear navigation for users - Support for older phones-No Bluetooth support

All testing with iBeacon triangulation using three beacons gave very messy, unreliable location results, and triangulation will not be used. In testing, triangulation results were greatly affected by uncontrollable variables such as metals in a room, or a hand or other object blocking the phone's Bluetooth antenna. After looking on the internet for possible solutions, more and more users reporting similar issues were found. Large margins of error and general unreliability when only using BLE for indoor mapping were reported everywhere. [23] Another stack overflow user allegedly spoke with "an Apple engineer who actively discouraged me to go down this way".

Instead of using triangulation, every art piece will be combined with one beacon. Considering the amount of different pieces of art in Concordia and the distances between these pieces, the amount of beacons needed should not be outrageous. The difference in beacons saved if an

attempt at semi-accurate triangulation would have been used would very likely not have been very large.

This solution is not one hundred percent perfect either, however. While a lot more accurate than triangulation, the iBeacon – phone distance measurement was still relatively slow. Even on all standard beacon detection apps that were tested (Flurp Laboratory’s ‘Beacon Scanner’ [24], Beacon Inside’s ‘Beacon Manager’ [25], Radius Network’s ‘Locate Beacon’ [26]) it usually takes the app a few seconds to update the phone to beacon distance. This means that if a user moves through a museum quickly, the distance estimate will not be accurate. Since most visitors are likely to take their time and not move constantly while in the museum, this is considered to be less harmful than the bad estimates triangulation gave.

Because of the chosen solutions possible unreliability, iBeacon ranging should not be used for any major tasks. For this reason the choice was made to use iBeacon distance as a visual indication of how nearby a piece of art is on a map. Because the buttons for the nearby pieces of art are bigger and more inviting than the ones that are further away, this should be a very intuitive way of navigating. Without changing the app’s settings, this is the only effect beacons have on the application. However, users can opt to turn on ‘Automatic Tour’ in the settings menu. When this is activated, the app will automatically switch between activities if a user comes in range of a new piece of art.

In an attempt to exclude as little user groups as possible, the app also works if a user’s phone does not support BLE or if the visitor does not wish to turn Bluetooth on for whatever reason. If they have their Bluetooth turned off, the visitor will be notified that turning it on will unlock more features in the app – but it is not mandatory. With Bluetooth turned off, the circles indicating the distance to a piece of art will always remain the same size, and Automatic Tour will not be available.

Adaptability

Adaptability

One of Concordia’s requirements was that the app should be adaptable to future exhibits. This is not an easy task, as the locations of the beacons change, as does their content, and the amount of beacons used. This makes it impossible to give descriptive names to beacons without having these names be incorrect in some cases. To make this beacon layout user friendly and semi-identifiable, all the art beacon activities are numbered, and the iBeacon they reference is fixed. E.g. the “FirstActivity” will always reference the beacon with minor number 29977. Preferably, these minor numbers would have been changed to something more matching such as 10001, however as I am not the owner of the beacons used in the test setup this is impossible.

To then get the iBeacon to the right place, Concordia can move a beacon to a desired spot, and change the firstCircleX and firstCircleY variables to their desired locations. Once Concordia has determined where the beacons and circles should be placed, they can simply change the image file or the stings.xml and the app will change the activity’s images. There is only one small issue with this system, and that is that the system might not handle certain inputs perfectly. For example, a very large image can be displayed and used in the app, but it will take up a lot of phone memory, which could cause the app to skip frames.

To help Concordia with these editing steps, an online form will be created where Concordia can enter the desired variables in the correct field, press submit, and the page will then produce appropriate code.

Content management and maintenance

Provide short descriptions of objects - Information deprivation, feeling of interest - Uncertainty or conflict arousing states - A right balance in curiosity states - The right difficulty level in information provided - Encouragement, interesting content, enjoyable experiences that engage the visitor - Audio, visuals, and interactive multimedia presenting real world scenarios

Many of the comments in the list above mention how the content in the app should be presented (e.g. provide short descriptions of objects in guidebooks). Options for implementing this content will be facilitated in the apps design, but since Concordia will maintain and update the app the way they choose to present content is always going to be their decision. A maintenance and update guide will be given to them once the app is completed, but nothing will stop them from completely ignoring this list if they so desire.

4.4.1 SPECIFIC APP SCREENS AND ELEMENTS

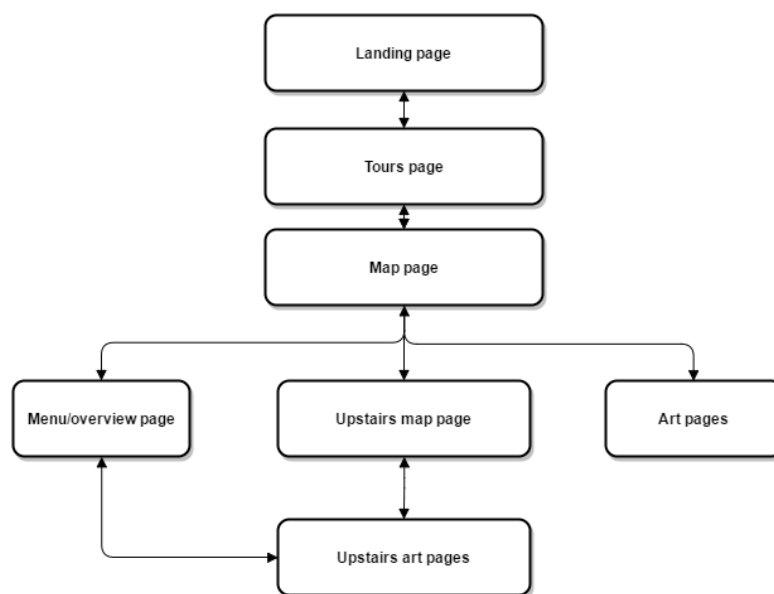


FIGURE 5: CONDENSED OVERVIEW OF APP NAVIGATION

Specific screens and elements from the app will now be discussed. A condensed overview of how the screens are connected to one another is shown in figure 5.

Menu/Overview interface

Information about upcoming events

This overview will consist of three different tabs

The first tab contains a list of all the current exhibits in the museum. The list is expandable; every parent exhibit has a list of

all its child items in it. Once these items are clicked, you navigate to the corresponding art page. This allows users to search for a specific item in the museum without having to look for its image

The second tab has an overview of all of Concordia's planned upcoming exhibits. The exhibits all have small preview images with overlaying text to introduce the user to the upcoming exhibit. Just like the landing page, this page must have appealing aesthetics that look inviting to the visitor. When a user clicks on an image, they navigate to a page about the upcoming exhibit, this page has the title of the exhibit/event, event date, and a short description of the exhibit/event.

The third tab of this overview activity has a settings menu, where the user can activate or deactivate autotour. A short description of autotour is also on this page. By activating autotour, the app will automatically display the information page of the nearest piece of art.

Tours menu

Different tour lengths - System to prevent users from getting the same information when they change tour length

In order to let users select tours of different lengths, an overview page will be used. This will be a very straightforward page, with three buttons and three descriptions, one button and description for every tour option. If we want to use a system that prevents users from seeing the same information even after they change tour length, that could be implemented here. The app can remember which tours have been previously activated here and send this information to the other activities.

This is the part of the app where beacon scanning is started in the background. If we want the next (map) activity's circles to be the right size upon load, we will need to acquire the distance data before the activity is loaded.

Landing page

Multilanguage support -

This is the first page visitors will see once they have downloaded and run the app. It is important that this page leaves a good first impression, the aesthetics of this page are very important. We also want to introduce the visitor to the basics of the app and possibly the museum. However, we also don't want to discourage the user by using a lot of text.

Because one way or the other, this page will contain text, it's important to allow the user to change their language options here easily. Therefore, a button with a German flag on it is used here to let visitors change their language to German. The main language of the application will be Dutch, as most of Concordia's visitors are Dutch.

This page also gives users a popup if they have location permissions or Bluetooth turned off. While the app was created in such a way that even users who do not want to allow location or Bluetooth permissions (or whose phones do not support BLE), some features work better with these turned on. This popup informs them of this, and reminds them that while allowing these permissions is not required, it is highly recommended.

Map and Navigation

Information about exhibits - Provide random access to information about objects - Providing a method of selecting objects visually- Letting learners learn at their own pace- A map of the museum- Clear navigation for users- Completion bar - Invited visitors up the stairs

Combining the factors summed up above, the specification for a map overview was done. Since users benefit from being able to navigate an app easily, and museum comfort is improved by providing a map, combining these two is a very straightforward solution. The main navigation tool the visitors will use to select pieces of art and walk around the museum will be a map indicating where the art pieces that are available in their tour are, and how close they are. Since there is no fixed order in the tour, this approach lets user access all the information about the art in a random. It also enables them to learn and explore at their own pace.

Providing a method of selecting objects visually was another factor that was important for the social, facilitator visitor group. For this reason, the selection of art pieces will be done by clicking on an image of the art.

The final overview page should feature a simplified map of Concordia's floors in the background, and circles representing real exhibits. To allow for many different exhibit circles to be displayed on one interface, while still having them all be big enough to be clickable even on small screens, the interface has to be scrollable. This way, even small resolution screens can navigate the large resolution map with ease.

Having a large amount of big circles on one screen might be overwhelming to a user. While the scrollable interface prevents some of the circles from being visible, this might not be enough for some users. Users will also probably be less interested in receiving information about pieces of art that are further away from them, as they might not even be able to see the art. Combining these two aspects inspired the solution created in the app. The circles representing the art change in size depending on how close a visitor is to the circle. The circles also feature smaller ripple circles around them, to represent the broadcasting element of the beacons.

Depending on which tour length the user has selected some circles are not visible.

A problem Concordia's representatives mentioned they struggle with was that some visitors do not understand that they are allowed to go upstairs, and that there is more art there. To welcome people upstairs, a circle telling you about the art upstairs is shown on the map activity. Of course, this circle – like all the others – can be turned off if the tour length does not give the user enough time to actually explore the upstairs area

This page will be the main overview page, and it is therefore very logical to equip it with a completion bar. This completion bar will inform users of how much of their tour they have so far completed. According to Myers [22] users find progress bars useful, and have a strong preference for a progress indicator when doing long tasks. Aside from this scientific fact, a progress bar will also be useful for my app in particular, as the user needs to scroll on an interface to find more circles. It will be frustrating to the user if they spend time looking for more circles while in fact, they have already seen all the circles available.

This is also the page where the user tracking could take place. We can log how much time a user spends where to get an idea of what exhibits visitors find interesting, and what they don't. This information could then be sent over the internet to a server. There is a downside to this however, and that is that at the moment the app requires no internet permissions. The user only needs an active internet connection to download the app. This is convenient because the entrance of Concordia's museum is in range of one of Enschede's free wifi spots. The reception of this network is unreliable inside.

Art pages

Text based information – Information about exhibits – Audio tour options - Support audio presentation of descriptions- User alert when a user is about to leave the audio range - Support for new media(large image zoom)- Clear navigation for users - Letting users share their thoughts and opinions on the art pieces with other visitors - Providing a way for visitors to share descriptions of objects

The art interface should feature an image of the art piece it represents, its title, the artist, and a description of the art piece. It should also feature a media player, which can be used to play various types of audio, such as an audio tour for the object. This is a main requirement for the facilitator group.

If a user clicks the image in the interface, they get an uncropped, unedited version of the image. There is a small white circle with a zoom icon to show the user that this image is zoomable. They can then pinch zoom and scroll on this image to explore more of its details. This should meet the needs of both the professionals and the explorers, as it inspires curiosity and allows visitors to get a closer look at the art. This imagebox could also support videos, and other new media objects to make this page more innovative.

Since most of the users will probably reach the art interfaces through the map overview, there should be a button on the bottom to return to the map. This should allow for easier navigation

These pages could also be used to let visitors share descriptions of objects. Through a simple (share on social media x) button users can upload an image of the art and include their own personal description. This description could then also be displayed in a separate textbox in the app for all the other visitors to see. This “other visitors think” box lets users share their thoughts with other visitors.

5. REALISATION

In this chapter, the realisation process of creating the specified product from the previous chapter is described. This chapter will explain the realisation on a per-activity basis. Some more general elements such as navigation will be discussed individually. The approach used during this realisation process was iterative with informal testing.

The prototype made in this chapter was created using Android studio. While the programming was a large part of the project, it will not be described in much depth, as it was a very linear process where more and more elements were gradually implemented over time. The full code and assets of the project can be found [here](#). In the following paragraphs the word “Activities” will be used, this is an android term for single screens with user interfaces.

5.1 NAVIGATION:

Before delving into in depth information about the app’s navigation, it is important to somewhat get an overview of the structure of the app, a complete overview of the structure of the app can be found in figure 6.

One of the high priority elements from the functional specification was “Clear navigation for users”. Users should not need to perform many steps to reach a desired screen. The possible ways of getting there should be clear and users a user’s navigation choices must be non-destructive.

Imagine a scenario where a user did not read or remember any of the information in the tutorial, and out of desperation simply starts clicking around. Because of the way the navigation has been arranged, even in this worst case scenario the user will always be able to reach the desired window in a limited amount of button presses.

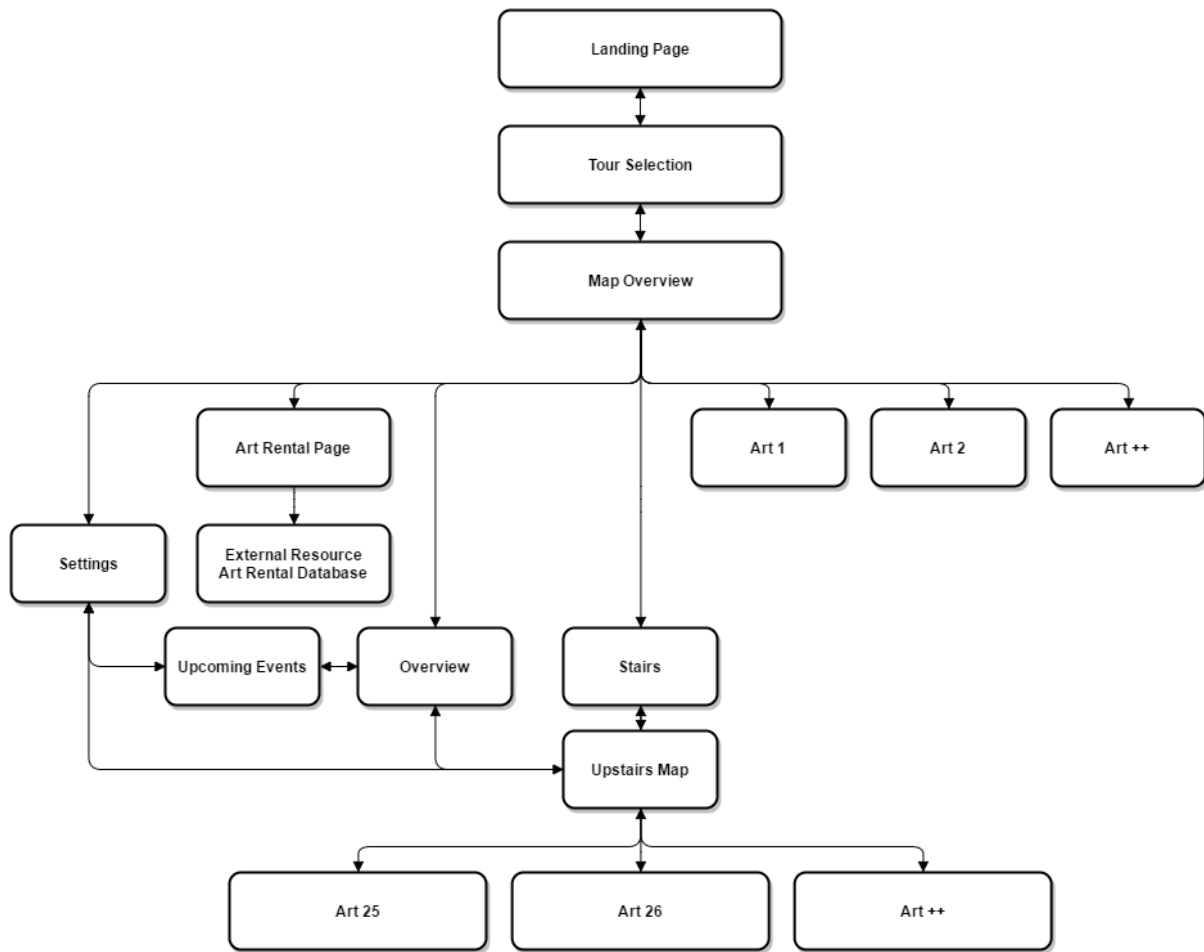


FIGURE 6: COMPLETE APP NAVIGATION FLOWCHART

5.2 LANDING PAGE:

As is described in the functional specification it's very important that the landing page looks neat. To both explain the concept of the app and make a nice looking landing page, a graphic was designed showing how iBeacons will be used in this app. This both matched the aesthetics requirement and the information requirement.

In an even earlier prototype, the German button contained text instead of images. However, the image is probably the most reliable solution, as users will probably not read any text if they can not understand any of the other text on the page.

After this prototype, the decision was made that the landing page needed to look more impressive and inviting. While the illustration was interesting, it needed more. Based on the previous prototype, this new interface was designed. It features a darker version of Concordia's background. The higher contrast between the background and the text also makes everything more readable. A Dutch flag was also included to create a nice symmetrical effect, and to allow us to keep the exact same interface for both the German and the Dutch landing page.

To make this interface less static and to make the main clickable element even more obvious, a blinking animation was made. This was done by putting a white version of the blue button right under the blue button, and then adding a transparency changing animation to the blue button.

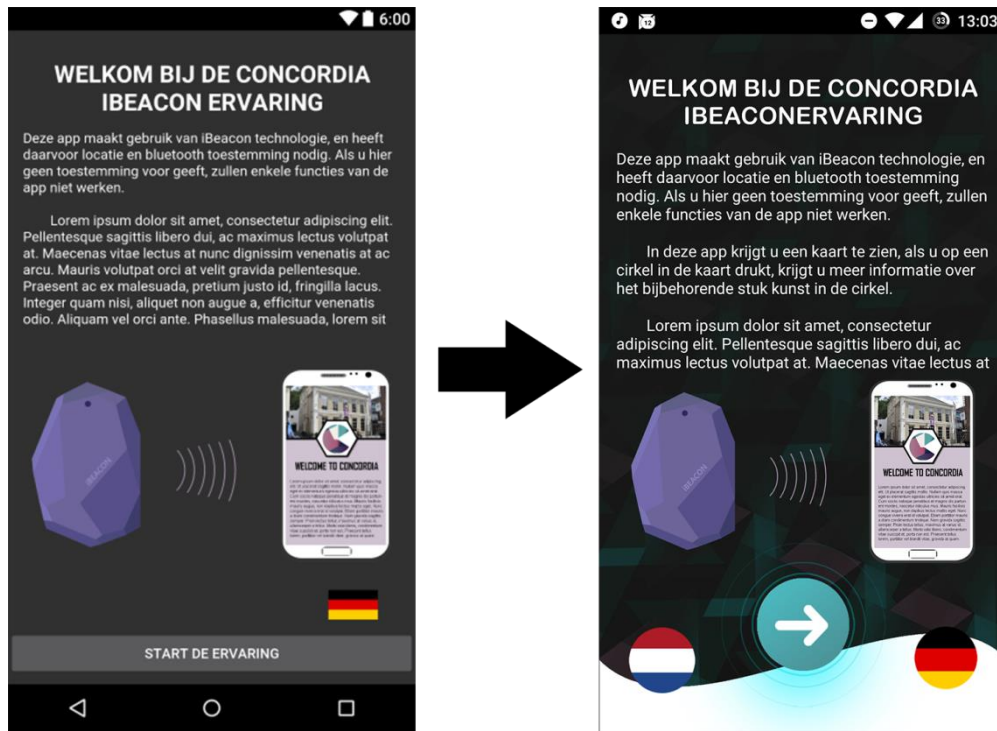


FIGURE 7: INTERFACE DEVELOPMENT OF LANDING PAGE

5.3 TOUR OVERVIEW:

The code for this activity's java class is very roughly based on AltBeacon's Android beacon reference app RangingActivity class. This class sets the beacon scan periods and stores the environmental variables for beacon distances, closest beacons and tour types.

It also initializes the beacon scan and sets the regions it should start scanning in. The regions are defined by their unique minor number. The app then sorts the found beacons and collects their distances.

The tour interface development steps are shown in figure 8. The simplest prototype of this interface was shown to three potential app users, and the users then gave feedback. One user remarked that it was unclear which button belonged to which description – they were not clearly grouped together. Comments were also made about how the text was too big. While the text should be readable even on smaller screens, very large text looks unpleasant on large displays. Using this user feedback, the following interface was designed.

This interface uses different coloured rectangles and indenting to clearly group the descriptions and the buttons. These are also small avatars to make the interface more aesthetically pleasing. The text size has been decreased slightly to make it look better on larger screens. The layout objects are entirely declared relative to the other objects, to support multiple screen sizes and resolutions.

While this interface certainly met all the requirements, it no longer suited the style of the landing page after its final change. Therefore the background of this interface had to be changed too. After this change, the buttons clashed with the background, so these needed replacing.

While the new buttons went well with the background, during an informal test, the tester remarked that they did not appear to be clearly clickable, so they were replaced with more obviously clickable buttons

Now that the interface has been completely fleshed out, and the background of the landing activity and the tour activity are the same, a smooth slide animation was applied when changing between activities.

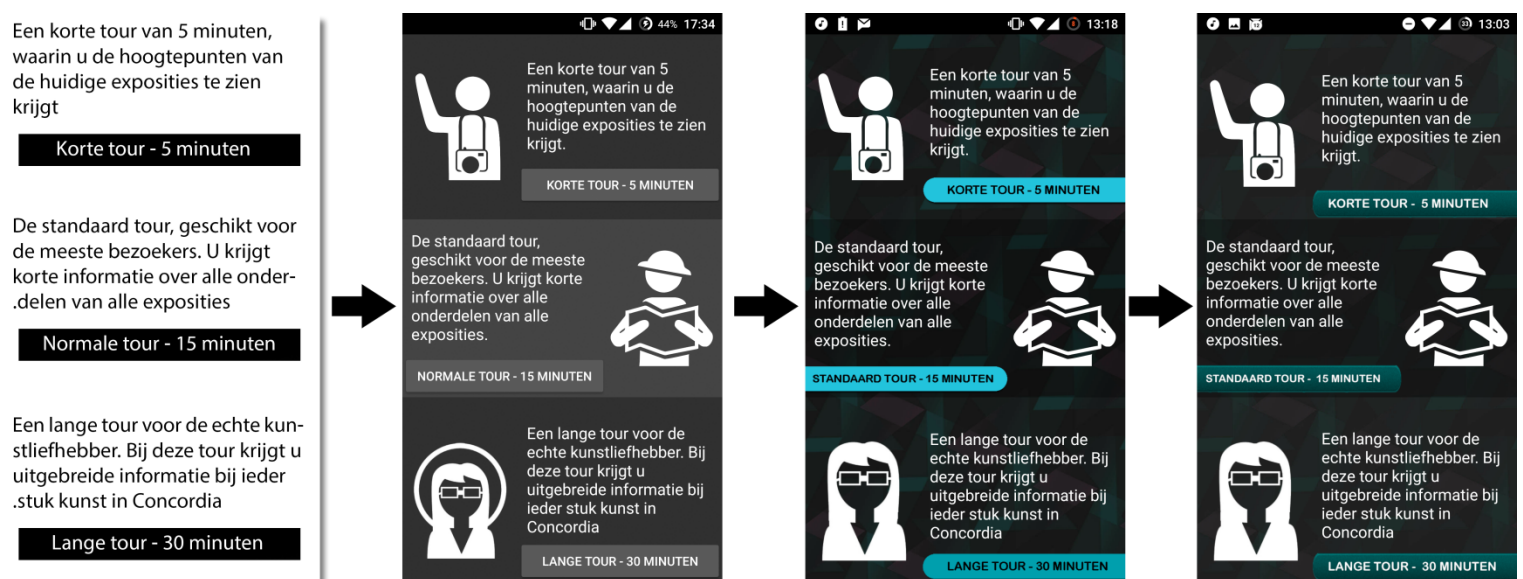


FIGURE 8: INTERFACE DEVELOPMENT OF TOURS PAGE

5.4 MAP OVERVIEW:

One of the requirements for the experience seekers and the rechargers was to have a map with images of key exhibits, which is reinforced with signs. Considering the fact that this map needs images of the exhibits, this map would be very fitting to be used as an overview and navigation page. Having an in-app map that is used as a page for navigation should also feel very natural and intuitive to users.

During testing, the realisation was made that having the app start in the top left part of the screen is very illogical. The visitors enter at the entrance, after all, and not at the top left of the map. This was changed.

During informal testing, it was also remarked that it wasn't initially obvious that this interface was scrollable, or that the circles were clickable. Every tester eventually managed to interact with the circles and scroll the view, but this was seemingly only because they didn't see any other options for interactions and were just clicking around. Using this feedback a short overlaying tutorial screen was added that loads on the first initial start of this activity. If the user touches the screen outside of the tutorial rectangle, the rectangle disappears.

A settings button was also added to this view. The settings menu only contains options that can be set that change this particular view, so it should be easily accessible from this view. A completion bar was also included in a later prototype.

5.4.1 CUSTOM LAYOUT

This activity is quite visually complex; it's a CustomView in a TwoDScrollView, with two xml layouts overlaying it.

The CustomView consists of all the custom art circle elements, and has an onDraw function that updates the CustomView every tick using invalidate. Outside of this CustomView, a bitmap gets loaded and gets cropped to a circle shape. Then, using a scaleDown method, on every onDraw loop the sizes of the circles get updated using their respective beacon distances and arbitrary variables like circleSensitivity and maxCircleSize.

Then, after checking if the circle should be visible using its respective 'xCircleVisible' Boolean if will draw a custom circle with ripples using the circleClass. The onDraw function will then perform the autoTourSwitching if AutoTour is turned on. onDraw will also update the progressBar's progress and text every tick.

Outside of its onDraw, CustomView has methods for checking if a click is inside a circle and if a touch event is a click. After some early prototyping it turned out it was necessary to differentiate between drag events and click events. When a user would accidentally drag to scroll over a circle, it would count as a click event, which is almost always undesired.

Using the CustomView described above, we create an initial layout. We create a customView and a scrollView based on our CustomView and an open source TwoDScrollView class from the 'The Android Open Source Project' [27]. We then add the customView into our scrollView and set our contentView to the scrollView. Now to add the two overlaying xml elements, the tutorialView and the map overlay view.

One major issue this map activity had was memory management. Android only has a very limited amount of memory at its disposal, and drawing a large bitmap in the background with many other bitmaps over it is a sure-fire way to run out fast. To save memory all the images

have been made as small as possible. The 2700 pixel wide background is actually a very large gif, that was exported using only 6 colours, thus making it only 36kb big, while looking a lot better than an over compressed jpg.

While this does solve some problems, if many circles are created or the images not scaled down properly before adding, the app will still load slowly and skip frames. To make sure slower phones don't have to wait for several seconds without seeing progress, a loadViewTask was created. This task loads bitmaps in the background while displaying a loading bar. Once the loading is done our custom layout is loaded

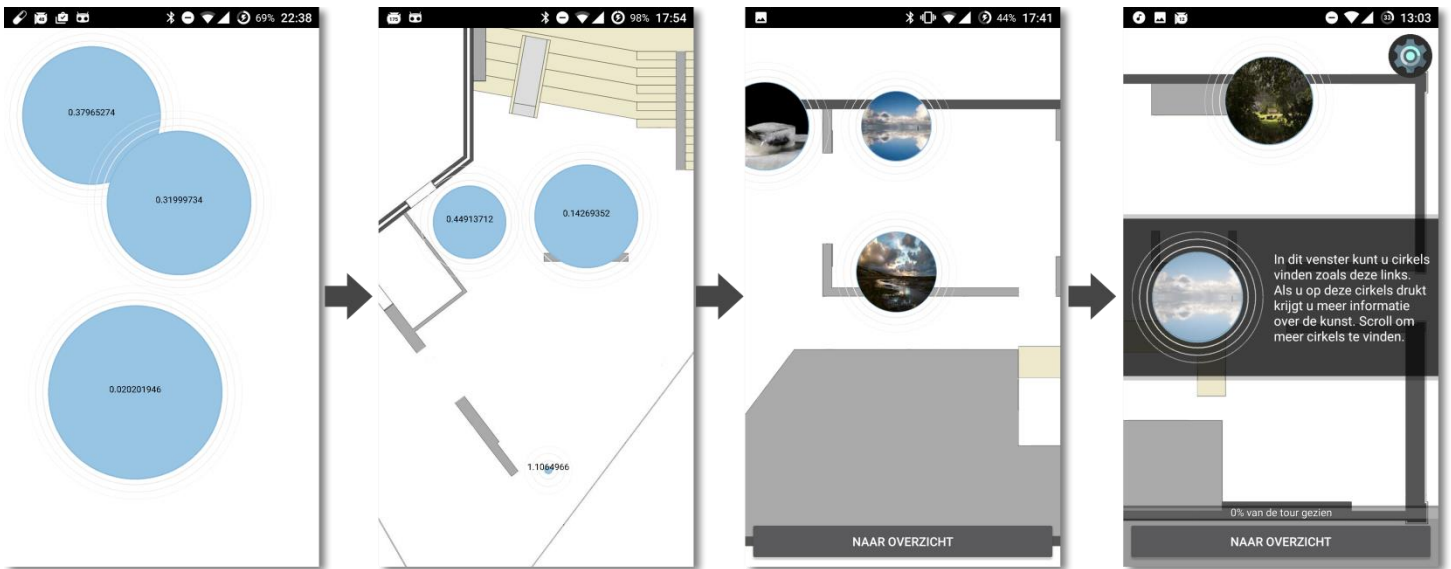


FIGURE 9: INTERFACE DEVELOPMENT OF MAP PAGE

5.5 ART INTERFACES:

If the “to map” button is clicked, the app will attempt to reorder the MapActivity to the front of the screen if it is still active.

The zoomable header image is created using an open source TouchImageView class created by Mike Ortiz [28]. This TouchImageView class extends androids standard ImageView and adds pinch zooming, dragging, double tap to zoom and more. The zoom from thumb animation was made using Android developer’s zoom tutorial [29]. This zoom from thumb animation works using two xml ImageViews, one expanded one which is invisible by default and a thumbnail image. On a click, the sizes of the thumb image and the expanded image get calculated, and the animation steps needed to expand the smaller image into the expanded image size gets calculated and executed.

There is also a modified version of this activity that includes a video player. If the video player button is clicked, three previously invisible views become visible, the black overlay, the close button and the video view. On this click, the mediaControls also get started. These mediaControls can be used to scroll through the video and control playback. If the user wants to stop playback they can click the close button to make the views invisible again.

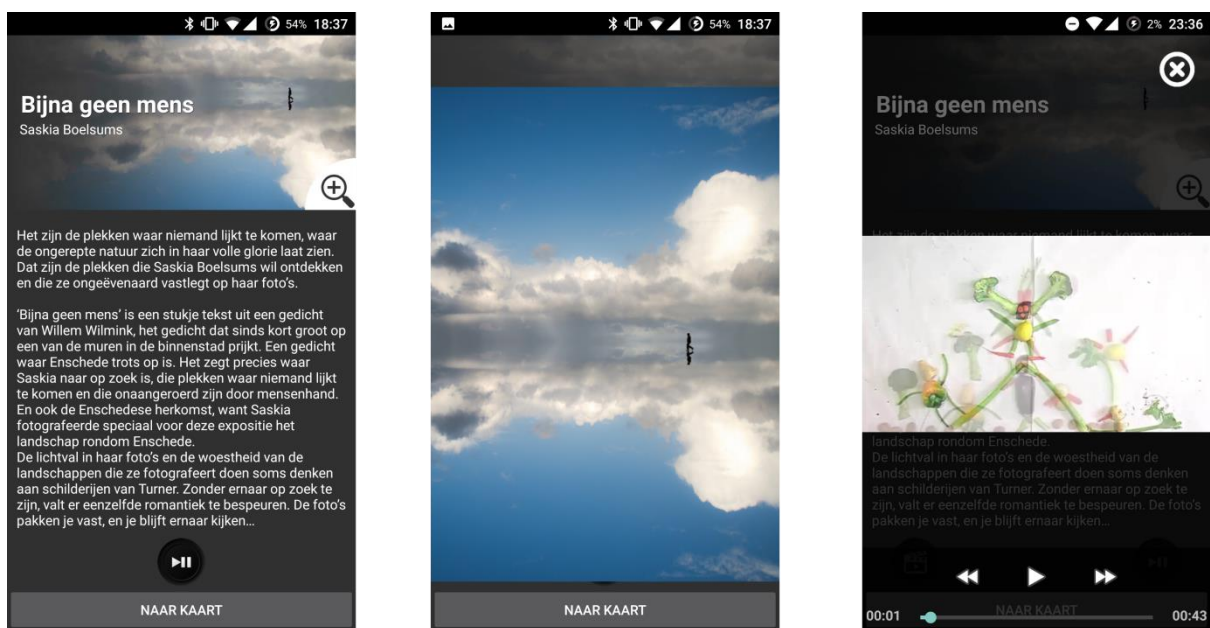


FIGURE 10: ART PAGE INTERFACE ELEMENTS

5.6 OVERVIEW INTERFACE:

FIRST TAB:

The first tab of this interface should have a list of all the pieces of art in Concordia. Using android's ExpandableListView this was implemented. However, this ListView is set to collapse all parent groups on first load. For Concordia, this means that only the titles of the current on-going exhibits will be visible. This looked a little silly, as it's a small museum and there are usually only two exhibits at any given moment. Therefore, this View was set to expand all on load instead. Later, this tab was also changed to include the same dark background with Concordia's squares that is seen on the landing page.

SECOND TAB:

When first trying to build this tab, it consisted of many images with text overlaying them. However, this made for a very long xml file, and it also had some issues with OnClick handling. Sometimes if a click was done on the text instead of the image it wouldn't register. For these reasons both of these elements were changed into one EditText block with a background image.

The overlaying text has a subtle drop shadow effect, so the text will be readable regardless of background image. Just like the landing page, this page must have appealing aesthetics that look inviting to the visitor.

THIRD TAB:

This is the settings tab where autotour can be activated. By activating autotour, the app will automatically display the information page of the nearest piece of art. It will only automatically change if the visitor is on the map overview or on another art overview page, so the visitor can still for example, navigate back to the settings to turn off autotour without the app overriding the navigation. While doing some personal tests with autotour turned on, I found it very annoying that I was unable to navigate back to the map overview without the app leading me back to the nearest art page. To introduce some more freedom in navigation and prevent this issue, an exception was added where the user will always be able to go back to the map page from a specific art page. This manual navigation will then not be overridden by the app.

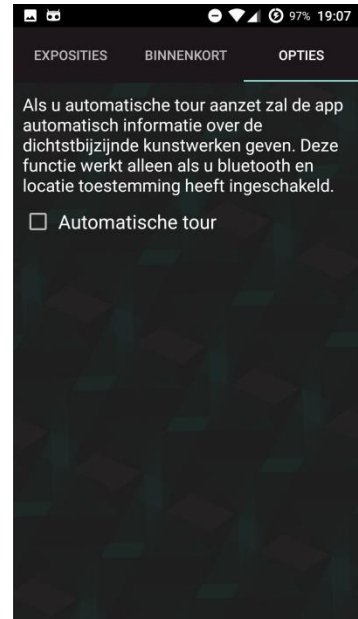
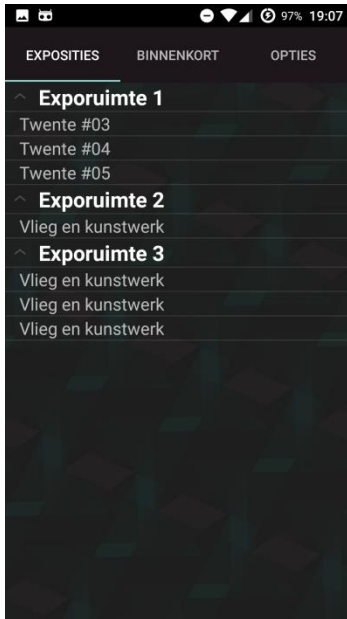


FIGURE 11: CONTENTS OF OVERVIEW/MENU PAGE

5.7 ADAPTABILITY:

One of Concordia's requirements was that the app should be adaptable to future exhibits. Concordia can turn individual activities on or off by changing a Boolean value to get the right amount of circles in their view. To move the beaconcircle to the right place, they need to adapt the circleX and circle variables. The strings in the activities can be changed in strings.xml, and the image assets can be changed by replacing the image in the drawable folders.

To help them do this, an online form was created that adapts the java code by letting a user fill out a form. A user can, for example fill out a value for the firstCircleX, and the form will automatically replace the firstCircleX value in the java code.

CircleX	CircleY	CircleImage	Visibility
firstCircleX <input type="text"/>	firstCircleY <input type="text"/>	Image for first circle <input type="text"/>	Set circle visibility <input type="text"/>
SecondCircleX <input type="text"/>	secondCircleY <input type="text"/>	Image for second circle <input type="text"/>	Set circle visibility <input type="text"/>
thirdCircleX <input type="text"/>	thirdCircleY <input type="text"/>	Image for third circle <input type="text"/>	Set circle visibility <input type="text"/>

Set the amount of visible circles

FIGURE 12: PROOF OF CONCEPT FOR ADAPTABILITY FORM

In its current shape, this is only a simple proof of concept. Using this concept all the variables can be changed in a user friendly way by Concordia, the form would only need expanding to actually make it function for all the activities. Filtering should also be added to catch input errors. If, for example someone at Concordia misspells "false" in the 'set circle visibility' field, the code will not run, as the Boolean only accepts either "false" or "true. To improve user-friendliness, Booleans could be replaced with check boxes, int variables should create a pop-up is an attempt was made to enter something that is not an int, etc.

6. VALIDATION

6.1 PRELIMINARY USER TEST

Using the functional prototype that was created in the previous chapter, user tests were done to find some last possible points for improvement and to get a general idea of the user-friendliness of the app. These user tests were done in preparation for the final user test.

The main research goal of this user test is determining the user-friendliness of the app and the ease of navigation so final improvements could be made before testing with real users.

APPROACH AND SETUP

In this preliminary user test, three different user groups were asked to perform the following tasks

TASKS:

1. Select a thirty minute tour - Count mistakes
2. Turn on "Automatic tour" – Count mistakes
3. Play audio information about a specific piece of art. - Count mistakes
4. Find information about Concordia's upcoming exhibits - Count mistakes
5. Navigate to the top floor - Count mistakes
6. What does the variable circle size mean?
7. Rate the user friendly ness of the app
8. Rate the layout of the app
9. Any other feedback?

The following user test groups were used:

- A. Experts – Individuals with app development experience or interface design experience.
- B. Tech aware users – Individuals with a certain extent of experience with technology.
- C. Technophobes – Individuals who have next to no experience using technology.

The tester did not receive any in depth information about the application before testing – a real visitor user would not receive any information outside of the app either. All the interaction information should become apparent from the application itself.

The test was done in Concordia, using a simple setup with three beacons and three in-app circles. The other circles have been removed so testers don't have any noise when trying to figure out how the circles respond to their movement through the building. The users were asked to pretend that they were touring through the museum and looking at the art, so that their movement patterns are alike to those of a real tour. Users are encouraged to verbalise their train of thought, and give feedback all the way through the test. All this feedback was then collected and combined as an answer to question nine.

RESULTS AND DISCUSSION

The results of the user tests can be seen below.

	Tester type										Average
Task nr.	C	B	B	B	C	A	C	A	C	C	
1	0	0	2	0	2	0	0	0	1	0	0.5
2	6	1	0	0	0	0	0	0	0	-	0.78
3	0	2	0	0	0	0	0	0	5	-	0.78
4	0	0	0	5	0	0	0	0	0	8	1.3
5	5	0	0	0	-	3	6	0	0	2	1.78
6	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes (80%)
7	2.5	3.5	4	4	4	3.75	4	3	4	2	3.48
8	3	4	4	5	4	4.25	5	4	4.5	4.5	4.2

A “-“ indicates that the user was unable to complete the task.

Task one – Select a thirty minute tour

Task one does not often cause problems for most users. The only issue found here was that three users expected the entire tour box to be clickable, instead of just the button. To help these users navigate, the entire box has been changed to respond to click inputs.

Task two – Turn on “automatic tour”

Task two also does not often cause problems. The only two testers who really had problems finding this option, were technophobes who were unfamiliar with standard phone layouts. To them, it was unclear how a TabView works. Therefore, they struggled with figuring out the navigation around the tabs in the overview menu. However, navigating using tabs is something that is used everywhere in app design, and it hardly ever causes issues for users. This would suggest that the two users who had some issues with tabs are simply very unlikely outliers.

Task three - Play audio information about a specific piece of art

Task three also doesn’t cause a lot of problems. One user navigated to the right page right away, but did not recognize the play pause button as being linked to music. To solve this, the play pause button for audio was changed to include a music note, so it is more obvious that this button activates audio.

One other user really struggled with this task, he was unable to complete the task. This was caused by this user not understanding the link between the tutorial circle image and the actual, interactive circles on the map. The user did not see that these represented the same circles, and did not recognise the opportunity for interaction. Since this user never clicked the circles, he was unable to turn on audio. To help this user see the link between the tutorial circle and the interactive circles, the circles could be given a more recognisable visual style. The current visual layout however, gets rated quite highly by users overall, so changing this might not be the best idea.

Task four - Find information about Concordia’s upcoming exhibits

Only two users had issues with this task, however, they did have major problems with performing the task, so this issue is worth addressing nonetheless. One of the two users who struggled with this task, also struggled with the previous task involving the TabView. This user still did not completely understand navigation through tabs and therefore had a hard time with this task. The other user only had a small issue with the phrasing on a button, which made navigation confusing for her. This tester struggled with understanding what the word “overzicht”, “overview” could mean in an app context. More users reported that this wording was a little awkward, so this button has been changed to “naar menu”, “to menu”.

Task five – Navigate to the top floor

Task five was clearly the most problematic one. Half of the tester had problems with this test, one of which was unable to complete the task at all. During this task, it was often reported that the image used to represent the stairs was a little unclear and dark. Testers also reported that they, since the stairs are in a similar circle to the ones containing the art, they thought this circle also represented a piece of art. To solve potential problems, the image was changed to a very universal icon for stairs. Hopefully, visitors should find this to be more easily recognisable as being a staircase while not being confused with a piece of art.

Question six – What does the variable circle size mean?

Eighty percent of the users understood the effect their location had on the circle sizes. The two users who did not see this pattern, were confused by the fact that sometimes the circles also change in size when you are standing still. This noise could be reduced slightly in the app, but changing this would also slow down the entire scanning process, making detecting changes in location even slower. Since most of the testers understood the current setup, and the alternative also has a large downside, the decision was made to not change the detection settings.

Question seven – Rate the user-friendliness of the app

The average rating for app user-friendliness is a 3.48. Most users were positive about the user-friendliness.

Question eight – Rate the layout of the app

The average rating for app layout is a 4.2. Most of the testers were very positive about the app, often commenting about the nice, clean look.

Question nine – Any other feedback?

Users gave a lot of feedback, these are some of the points that were most often mentioned, and the solutions created to prevent future frustrations:

- Would like some text to go with the play pause button – Buttons have been changed to more clearly show what the button is activating.
- Tutorial text should be shorter – All the three sentences in the tutorial view have been reduced in length. According to [30] sentence length severely affects sentence recall. Since the information on this screen is necessary for the user to understand the activities, it is recommended we keep this text as short as possible.
- “Links” reads as a web link, not as “to left of”. – The wording here has been changed.
- Map should be pinch zoomable – Since the entire map view is built up out of four complex, different layout files, it is very challenging to implement pinch zooming while

still maintaining a smooth drawrate. This could be an interesting feature to add in the future, but is not reasonably creatable within the scope of this project.

- It's unclear that users can press their phone's back button to go back – This is very likely a problem caused by the tester not testing on their own phone. All android phones have access to back buttons, either physical or on screen, and pressing back to go back is very obvious to android users. [31]
- Autotour should be turned on at all times – Due to the unreliability of autotour and iBeacon's signals having autotour on could give unwanted results.
- Expositions tab should not be sorted by artist but by exposition room - Changed
- The circles changing in size is too subtle – It is recommended to keep these changes subtle. In the test case, only three circles were used, as only three beacons were available at that moment. However, in a real tour, more circles would usually be displayed on one screen. Having a more obvious animation could be very overwhelming in that case.
- Map needs some descriptive text to help people orientate. – Added expo numbers and labels for the entrance and reception.
- The phrasing on the “overzicht” button is awkward – This button has been changed to read “menu”
- Stairs image is ambiguous – The image has been changed.
- Audio play should have different icon, featuring headphones or something - Changed
- Map has some weird walls that change width etc. Should be simplified so it'll be less distracting. – Walls now have uniform width.

6.2 VISITOR USER TESTS

Using the prototype feedback from the last user tests, a final prototype was created. To try and estimate whether the app actually improves the visitor experience, the app was given to real visitors in Concordia and they were asked several questions. These questions are based on the visitor motivations established in the first chapters.

The research goal of this test is to gain insight into how the app influences the previously established visitor motivation factors, and by extent the visitor experience in general

APPROACH AND SETUP

Visitors in Concordia were given an app and asked to explore and interact with it as much as they like, while continuing their exploration through Concordia. The app has the same setup as that of the preliminary user tests, except the art pages have been changed to actually present relevant information and video content. Once the visitor felt that they were done with the app or their exploration, they return the phone and answered the following questions:

1. Does the application affect possibilities for social interaction?
2. Does this application affect your motivation to visit the museum with friends and family?
3. Does this application change your ability to explore and learn about art?
4. Does this application give you the opportunity to a more gain in depth knowledge about art?
5. Does this application affect the amount of fun you have at the museum?
6. Does this application affect how much you feel at ease in the museum?
7. Does this application change your opportunities to recharge and escape everyday life?
8. Does this application change the feeling of doing something worthwhile in the museum?
9. Does this application change your feeling of actively participating in the museum?
10. Does this application change your appreciation for the quality of the art?

Answers were given on a scale from one to five, one being “worsens considerably”, two being “worsens”, three being “neutral”, four being “improves”, five being “improves considerably”.

The mean of the answers per question and answers per user will then be calculated to determine how all questioned visitors feel about the user experience changes, and to determine how happy the individual visitors were about the application.

RESULTS AND DISCUSSION

The bar chart of the results and their standard deviations can be found in figure 13. All of the ten individual visitors who were interviewed thought that on balance, the application would either improve, or not change their visitor experience. All the means of the individual’s scores are above neutral (3). Several visitors indicated that they were not really interested in an app, but since its usage is not mandatory they can always opt not to use it. This would leave their visitor experience relatively unchanged.

The general visitor reaction to the impact the app would have on certain aspects of their experience was very positive. All the impacted factors were rated above neutral (3).

Since both all the individual visitors rankings and the general element rankings of the app were positive, it can be concluded that the application positively affects the individual and general user experience.

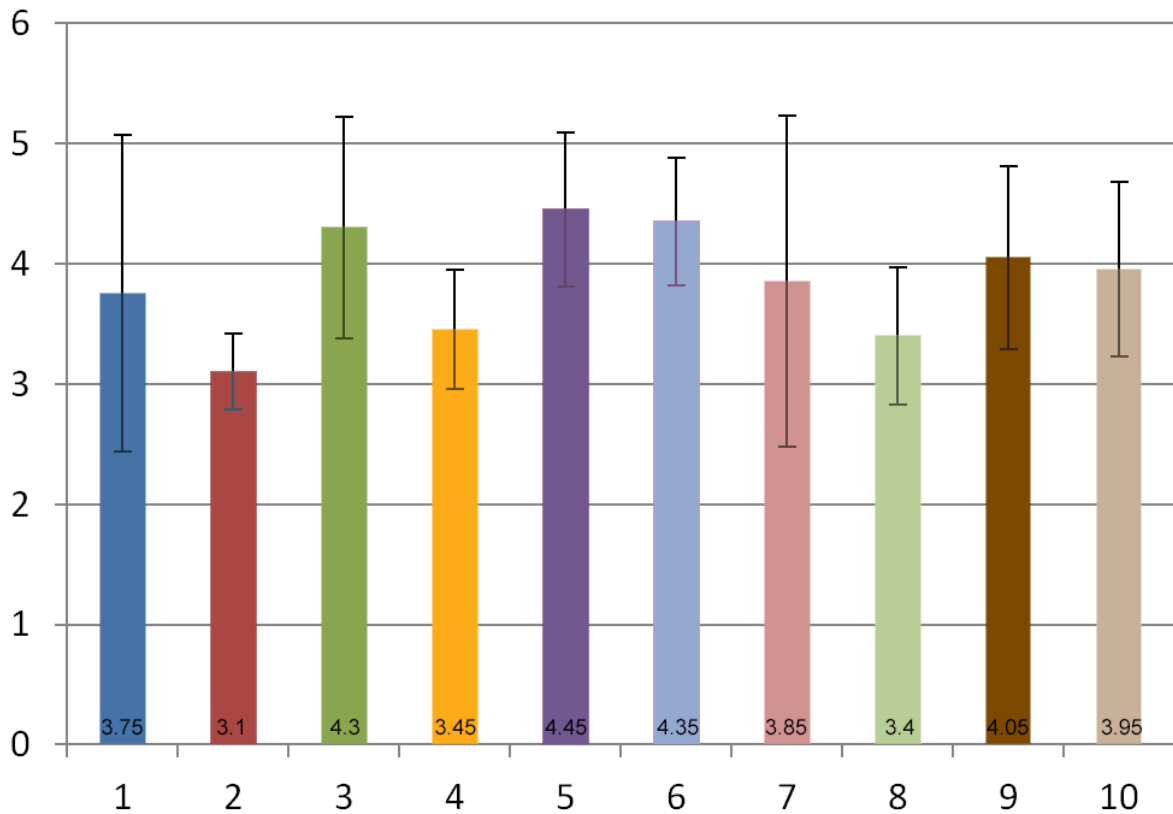


FIGURE 13: MEANS OF VISITOR EXPERIENCE ELEMENT RATINGS

- Affect possibilities for social interaction?
- Affect your motivation to visit the museum with friends and family?
- Change your ability to explore and learn about art?
- Give you the opportunity to a more gain in depth knowledge about art?
- Affect the amount of fun you have at the museum?
- Affect how much you feel at ease in the museum?
- Change your opportunities to recharge and escape everyday life?
- Change the feeling of doing something worthwhile in the museum?
- Change your feeling of actively participating in the museum?
- Change your appreciation for the quality of the art?

INFORMAL OBSERVATIONS

In addition to the survey results, some informal observations were made. The exact academic value of these observations are hard to determine, as no previous, formal observations were done to compare them to. However, they will be included nonetheless, as more of an informal side note, and will not be included in the conclusion.

- Testers seem to spend more time looking at and reading about art. This could be caused by the fact that the app simply gives more information than Concordia did before, which takes longer to read. However, it could also reflect tester interest.
- Testers were very positive about being able to take the information and images in Concordia home with them, using this application
- Elderly visitors seemed to be especially excited about the automatic tour function. The simple navigation was very appealing to them.

7. CONCLUSION

Concordia wants to draw more visitors to their museum. This can be done by improving the general visitor experience in the museum, which improved visitor satisfaction and should help non-visitors become occasional visitors through excitement and word of mouth, and occasional visitors become frequent visitors.

To improve the visitor experience in Concordia, literature research was done into visitor motivations and factors influencing visitor experience. Using this literature several design guidelines for improving visitor experiences in a museum context were created and collected. These guidelines were then combined with the functional requirements of the project to help the creation and specification of concepts. Through a selection process, one final concept was chosen – a self-guided tour app.

This app was then developed using all the pre-established guidelines for museum experience design, recommendations and requirements from Concordia to improve the chances of creating a successful project. The developed hifi prototype was then thoroughly tested to prepare it for final testing with real visitors.

According to the preliminary user test, a nice looking, and generally user-friendly app was created. Testers were able to navigate and use the app with relative ease. The elements that caused issues in user testing were ironed out after this test, leading to an even smoother user experience.

The visitors questioned during the visitor user tests were positive about the application. Both the individuals' experiences and general ratings for user experience changes were all higher than neutral. This would suggest that the application positively influences the visitor experience, and should increase the amount of visitors visiting Concordia.

7.1 RESEARCH QUESTIONS

In this short subsection, the research questions will be repeated and short summaries of their answers will be given.

RESEARCH QUESTIONS:

- What kind of museum visitors are there?
 - Demographics are not useful for this project. By sorting people by their visitor motivations however, nine unique visitor motivations can be found that accurately describe museum visitors.
- What are the differences in their visitor experiences?
 - Every visitor groups has specific needs that they look for, and value more in museums.
- What factors influence whether an individual visits a museum?
 - In order to draw more visitors, individuals need to see a museum as a place where their needs can be fulfilled.

DESIGN QUESTIONS:

- What are the design possibilities of iBeacons?
 - iBeacons can estimate a distance between a user and a beacon. This information can be used for indoor tracking. In addition to discussing these technical capabilities, similar systems exploration was done to see what this versatile product can be used for.
- How can the factors found in the research phase be used to make a more successful product?
 - The design possibilities give more insight in what can and can't be done with iBeacons. The visitor motivations were used as a starting point for developing design guidelines for museum visitors. Using these guidelines in design should improve the visitor experience and make a more successful product.

VALIDATION QUESTIONS:

- Is the developed product user friendly and easy to navigate?
 - To estimate the user friendliness of the application and its ease of navigation, testers were asked to perform several tasks in the application, and rate some elements. Tester feedback from this stage was used to further improve the application in preparation for the final visitor test.
- Does the developed product improve the visitor experience?
 - Real visitors in Concordia were asked to experience the museum with the application. Afterwards, they rated their change in visitor experience. On average, visitors reported a positive change in most of the elements of their visitor experience. Some elements were reported to be uninfluenced by the application, but on balance no negative effects were reported.

7.2 LIMITATIONS AND FUTURE WORK

In this chapter, the limitations of this project and recommendations for future work are discussed. While all the research questions have been answered to some extent, there is plenty of room for future work which would improve the quality of the project.

- Support for other operating systems
 - The prototype that was developed in this project is an android application prototype, no prototypes were developed for other operating systems. To let visitors who use other operating systems use the app too, a version would have to be developed for those operating systems.
- Zoomable maps
 - A comment that was often made during the preliminary user test was that the maps of the museum should be zoomable. It was not possible to implement this feature before the project deadline. Considering the amount of times this comment was made, this feature would improve user friendliness and orientation.
- More accurate tracking by combining iBeacons with WiFi.

- The current location tracking system only uses the iBeacons, which makes it rather unreliable. In order to improve the reliability of the location tracking, the iBeacons should be combined with other indoor mapping systems, such as WiFi positioning systems.
- More new media
 - One of Concordia's main requirements was that the delivered product should be adaptable, with the possibility of maybe adding more features into the basic app later. This leads to a lot of development time going into making a functioning, semi-modular app, leaving almost no time to actually create interesting content that could motivate users to use the app. It would, for example, have been very interesting to add 360 renders of art featuring sensorial rotation. This is the sort of innovative, interesting content that could actually convince users to start using the app.
- More social and interactive features
 - The application has limited social and interactive features. Adding these should make the application more enjoyable for socially motivated visitors and visitors who long for interactivity.
- More testing
 - The prototype was tested many times throughout the development of the project. While the results from these tests were useful and usable for this project, they would have been more reliable if the amount of tests done was higher.

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APPENDIX

Name and source:																		
Apple iBeacon briefing http://link.springer.com/article/10.1057/dddmp.2014.7	Static point of interest	Indoor mapping	Two-way proximity	Analytics														
Groninger museum http://www.groningermuseum.nl/node/2622	Interactive apps	Info about art	Games	Learning														
Beaconstac https://blog.beaconstac.com/2015/02/3-museums-using-beacons-to-enhance-interactivity/	Location tracking	Games	Social media															
Retailers beaconstac https://blog.beaconstac.com/2016/02/25-retailers-nailing-it-with-their-proximity-marketing-campaigns/	Location tracking	Calendar	Coupons	Loyalty cards	Directions	Big data	Request s	Trade in phone										
Infoworld http://www.infoworld.com/article/2606357/mobile-technology/160948-7-cool-uses-of-beacons-you-may-not-expect.html#slide9	Location tracking	Improved learning																
EAT http://mobilemarketingmagazine.com/eat-trials-weves-beacon-based-loyalty-app/	Loyalty card																	
Woolworths http://www.cmo.com.au/article/566073/woolworths-plans-national-beacons-rollout-improve-click-and-collect-customer-service/	Easier shopping	Tracking																

APPENDIX A: SIMILAR SYSTEMS SOURCES

	Concordia	Feasibilit	Fun?	Facilitator	Explorers	Professio	Experienc	Recharger	History	Participat	Worthwhi	Quality	Storytellir	Learning	Social	Logistics	Inspiration			
Scavenger Hunt		4	5	5	5	2	4	1	2	4	2	2	4	2	4	2	4	3	2	3.25
Read more		5	3	3	4	5	2	3	4	2	3	4	2	5	2	3	2	4	3	3.25
"You might like"		5	2	2	2	4	3	4	3	2	3	4	4	3	3	4	4	4	3	3.25
Self-guided tour		4	4	3	5	5	4	4	4	4	3	5	5	5	3	5	4	4	4	4.1875
Gather visitor data		3	5	3	3	3	5	3	3	3	5	5	3	3	3	5	3	5	3	3.625
Personalized to user		2	4																	3
Separate interaction device		1	3	5	3	2	4	5	2	3	3	2	4	2	5	4	4	4	4	3.25
App on phone		5	4	4	3	4	3	3	3	3	3	2	4	4	2	4	3	4	3	3.375
Information about facilities		5	2	4	4	3	5	5	3	3	4	3	2	2	3	5	2	4	3	3.4375
Share on social media		5	1	4	3	1	3	3	2	2	1	1	1	1	5	3	4	4	2	2.5
Different length tours		4	4	5	5	5	5	5	5	3	4	5	4	5	3	5	5	5	5	4.5
Physical web		2	3	3	4	3	2	2	3	3	3	2	3	3	2	2	3	2	3	2.6875
Interactive quiz		4	5	5	4	4	3	2	3	5	4	2	4	4	5	3	4	4	4	3.8125
Augmented reality		1	5	4	5	4	4	4	4	4	4	4	5	3	3	3	5	3	5	3.875
Battle other visitors		4	4	5	3	3	5	2	3	5	3	2	4	4	5	3	4	4	4	3.6875
Users compose music for art		3	5	5	3	2	4	3	4	5	5	2	4	2	4	3	5	5	5	3.6875
Exhibition outside		3	3	3	4	3	3	3	3	3	3	2	3	3	3	1	3	3	3	2.875
Multilanguage support		5	3	3	2	4	5	4	2	3	2	3	3	4	4	5	3	4	5	3.4375
Artist's vision		5	4	4	4	5	3	4	4	3	3	4	5	3	3	3	5	3	5	3.875
Work in progress		4	5	3	4	4	4	5	4	3	3	5	5	3	3	3	5	3	5	3.9375
User's interpretation		4	4	4	3	3	3	4	3	4	5	2	4	3	5	3	3	3	3	3.5625
Displayed user reviews		4	3	5	3	3	3	4	3	4	5	2	4	2	5	3	3	3	3	3.5
Calendar		5	3	2	4	4	4	3	4	3	4	5	3	3	3	5	3	3	3	3.625
Zoom on paintings		5	4	3	5	5	3	5	3	4	3	5	2	4	2	5	4	4	4	3.875
Virtual reality atmosphere		1	5	4	4	2	5	2	4	4	3	4	5	4	4	5	5	5	5	3.8125
Beacons showing reviews		3	4	5	3	3	3	3	3	5	5	2	3	2	5	3	3	3	3	3.4375
Near me		4	3	3	4	5	4	4	3	4	3	5	4	3	3	5	3	5	3	3.75
Find your museum buddy		3	4	5	3	3	3	3	3	5	4	2	3	3	5	4	4	4	4	3.5625
Concordia loyalty app		4	5	2	3	4	2	4	3	4	5	4	2	2	4	3	2	3	2	3.3125
Find all the beacons		5	5	3	5	2	3	3	2	4	3	3	4	3	3	2	4	4	4	3.375
I could have done that too		2	5	4	3	4	5	4	2	5	4	1	4	4	3	4	5	5	5	3.6875
Music next to art		4	5	5	4	3	4	4	4	3	3	2	4	2	2	5	4	4	4	3.625
Compass		4	4	3	4	5	5	3	3	3	3	4	3	3	3	5	3	3	3	3.625
Completionist		5	4	3	5	5	3	2	3	3	4	4	4	4	3	4	4	2	4	3.625
Art changes if user gets close		3	5	5	4	2	4	4	2	4	3	3	5	2	2	3	4	4	4	3.4375
Crowd management		3	2	5	3	4	4	5	5	3	2	4	3	4	5	5	2	3	4	3.6875
Interesting statistics		3	3	2	3	3	2	4	3	3	2	3	2	3	2	4	2	4	2	2.75
Popularity map		5	2	3	3	3	2	4	3	3	2	3	2	3	2	4	3	4	3	2.9375
Environmental sounds		4	4	3	4	3	4	4	4	5	2	3	5	4	3	3	4	4	4	3.6875
Idea sharing		4	4	5	3	5	3	3	3	5	3	4	4	5	5	3	5	4	4	4
Storytelling show		4	5	3	4	4	5	3	5	4	3	2	5	4	4	3	4	4	4	3.875
Discussion space		3	3	5	3	5	2	4	4	4	4	2	4	5	5	4	4	4	4	3.8125
Rotate art		3	5	3	4	3	4	4	3	5	3	4	3	4	3	4	4	4	4	3.6875
How it's made		3	3	3	5	5	3	3	3	3	3	5	3	4	2	4	3	4	3	3.4375
Start sounds		5	3	4	3	3	3	3	3	5	3	2	5	3	3	3	4	4	4	3.4375

APPENDIX B: FULL MATRIX OF CONCEPT RATINGS

- Old woman
- Wants to visit with her family
- Is bad with technology
- Needs large buttons and text
- Loves museums
- Wants to enjoy art like she always has
- Visits for high quality of art
- Professional
- Consider how visiting with a group changes visiting dynamic

- Young male teen
- Hates museums because he doesn't have enough understanding of artists and their art
- Is sometimes forced to visit
- Needs more context to enjoy museum
- More likely to abuse created application
- Explorer visitor type in all his other pastimes
- Consider how affinity for museums changes visitor behaviour

- Middle-aged female
- Real tech lover
- Indifferent towards museums
- Once entering a museum, she is very likely to focus on tech wherever possible
- Experience seeker, mainly just wants to feel comfortable
- More likely to visit alone
- Should be able to learn about without being too distracted by the app
- Consider how ones preferences affect visitor type needs and experiences

APPENDIX C: PERSONAS USED