IT UNIVERSITY OF COPENHAGEN

Master Thesis

Playful Mixed Reality Interactions for Museums

Exposing Visitors to the Digital Collection

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Contents

List of Figures

Abstract

Museums are implementing and utilizing playful experiences in order to engage their visitor with their collections. Museum collections and expositions have emerged in playful experi- ences for the visitors to spark interest and engage the audience. Since digital devices are easily available, either as hand-held devices by the visitors, or as devices designed for embod- ied interaction used in the museums space, museums are trying to use the digital medium to enhance the experience of their visitors, and showcase their digital collection. These mobile devices are able to create an adjacent space, a space that connects the physical space and the virtual space of museums. That adjacent space materializes through mixed reality interactions. This project uses those mixed reality interactions, to connect those two spaces for the exhibition *A retrospective on Danish photographer Keld Helmer-Petersen* that will be showcased by the *National Museum of Photography*, in order to expose the exhibition's visitors to the digital archive with the life work of the photographer.

Keywords: mixed reality, museums, critical play, trajectories, playfulness

Chapter 1

Introduction

Modern museums consist of both physical and digital collections. The advancement of technology and the digitization of data, has created the possibility and the necessity for the museum space to expands beyond the physical space, into the virtual space. The visitors of the museum are able to explore with ease both those spaces, due to the technology being readily available(Sanderhoff, 2014). Due to the new possibilities created by the new technologies, museums need to adapt to the digital wave in order to remain relevant for society as cultural heritage spaces(Ulrich Tarp Hansen, 2014). That adaptation can only transpire through researching and understanding those technologies, and how those technologies can be modified to operate inside the museum context(Visser, 2014).

1.1 Research Question

The goal of this thesis is to research and analyze the following question:

> *How can playful mixed reality interactions be utilized by museums, in order to expose the museum visitors to their digital collection?*

Currently, digital technologies are utilized to both store and share the digital archives that museums possess(Sanderhoff, 2014). Those technologies can

connect the digital and the physical space of a museums through mixed reality interactions(Benford & Giannachi, 2011).

A mixed reality experience consists of interactions that contain both physical and digital elements, and connects the objects of those two spaces. Those real and virtual object form a *hybrid space* - a mixed reality space - inside which they interact in real-time(Benford & Giannachi, 2011).

In that mixed reality experience, the physical space contains the exhibition space, while the digital space contains the digital collection of the museum. Through that experience, the elements of the physical space - which is traversed by the visitor - are connected with the elements of the virtual space - the digital collection. The visitor is able to interact with those elements of the physical space, and through that they gain access to the virtual space. This connection could be formed with scannable objects, gps location, even cellular networks - as in *Day of the Figurines* a massively multiplayer board game where the players control their characters and affect the story by receiving and sending SMS messages(Flintham et al., 2007).

The goal of this thesis is to further understand the design and technology elements those mixed reality interactions should have to create meaningful museum experiences and capture the interest of the visitors.

1.2 Project Scope

As an attempt to answer the research question that was described, I designed and developed a mixed reality interaction using the critical play design model(figure 3.1), and the Trajectories Conceptual Framework(Benford & Giannachi, 2011) for the Keld Helmer-Petersen exhibition that is scheduled to open at the National Museum of Photography at spring 2019. The Keld Helmer-Petersen exhibition was selected since its digital collection contains over 16000 photographs. The large size of that digital collection is what allowed me to explore the research question of this thesis. Due to the nature of the exhibition, and the space that will host the exhibition, only a small subset of the artist's work will be present - small in terms of his lifework of over 16000

photographs. As a result, that exhibition is an ideal use case, since the utility of exposing a visitor to that collection is high.

1.3 Project Structure

Chapter 2 - Literature Review & State of the Art

In this chapter, I present a theoretical background from literature that exist in the field. Furthermore, examples of similar projects are referenced.

Chapter 3 - Method

During this chapter, I provide further details on the design methods with which I approached this project, as well as the evaluation methods that were used to analyze the results.

Chapter 4 - Results

Next, the design itself is presented, along with the prototype process. The various design desicions that were made during the research are analyzed in depth, in relation to the expert opinion and feedback, as well as the theoretical background. Finally, a detailed explanation on the playtests - how were they conducted, and their results - is presented.

Chapter 5 - Discussion

Having explored the relevant academic field, reviewed the design process, and tested the product, I present a qualitative analysis of the results. I review the objectives that were set in Chapter 4, and discuss what was discovered about those objectives through the testing process. Moreover, I present topics for further research regarding my findings.

Chapter 6 - Conclusion

I conclude my thesis by providing an answer to the research question that was posed, by summarizing my work and its results.

Chapter 2

Literature Review

In the following chapter I will provide an outline regarding the relevant fields that are related to my project, along with their state-of-the-art.

The scope of the project is to design a playful mixed reality interaction for the exhibition **A retrospective on Danish photographer Keld Helmer-Petersen** which will be displayed in the space of *The National Museum of Photography*, located in *The Royal Library*. Therefore, literature regarding playful and informative museum interactions is relevant to this thesis, along with contributions to mixed reality(Benford & Giannachi, 2011) and performance play. In addition, the primary goal of this project is to connect the physical exhibition space with the digital collection of the museum, thus, I will provide literature regarding the importance of that goal, and the value that museums attribute in exposing their digital collection to the public.

2.1 Museum Interactions

One of the main challenges modern museums face is inertia towards change, and towards newer technologies and opportunities(Black, 2012). The rise of modern media has impacted the way visitors relate to museums, since their expectations from the museum space have changed. Due to the advancement of technology, the attitude that society has towards engagement is shifted from passive to active. It is necessary for museums to adapt to this attitude and offer

active engagement with their collections and exhibitions to their visitors(Black, 2012).

In order to create active engagement, museum designers and researchers have developed and tested a plethora of digital artifacts. From the use of location-based content - via 2D barcodes - to digitally enhance the London Zoo(O'Hara et al., 2007), to using geotagging technologies and GPS technologies to extend the space of the museum into the public space(Giannachi et al., 2017), museums of the 21st century have been actively involved into intergrating their physical and digital collections through the use of hybrid interactions. The importance of this research field is supported by the extended attempts and literature regarding that integration (Laursen, 2014; Mann, 2012; Cosley et al., 2009; Fetter, Beckmann, & Gross, 2014; Ng & Shaikh, 2016; Albertini, Brunelli, Stock, & Zancanaro, 2005; Rung, Laursen, & Kristiansen, 2012). Those publications discuss both technological aspects and design aspects of hybrid interactions implemented for museum spaces. Museums attribute value in providing digitally enhanced informative content to the public. Interactivity is key to explore that digital content. To shape the nature of that interactivity, and create meaningful engagement between the visitor and the museum collection, museums rely on the field of design(Black, 2012).

Playfulness allows the visitor to appropriate the content of the museums, and through that appropriation the significance of the data can be explored, and new knowledge is revealed(Sicart, 2014). In addition to appropriation, playfulness is characterized by personalization(Sicart, 2014). Personalizing an experience through playfulness, creates an environment inside which the visitors are able to freely express themselves, and be creative on how they interact with the exhibits(Sicart, 2014). Those elements have already been incorporated into various designs, in order to research their effect on the museum experience(Giersing, 2014; Bryndum & Muhandes, 2017; Ingimundardóttir, Sachse, & Stančiauskaitė, 2017; Rubino, Barberis, Xhembulla, & Malnati, 2015; Ryding & Løvlie, 2018). When analyzing the state of the art of the field of playful design for museum exhibitions, different goals appear. A common goal is to educate the public(Bryndum & Muhandes, 2017). Consid-

ering the role of the museum in the society as communicating information to the public - that goal reflects the necessity to evolve from a model of passive learning, to a model of active learning, which incorporates the public into the learning process. Through that intergration, the museum can act as an intermediary between its visitors, allowing them to add contributions to the learning process, and through that creating and sharing life experiences(Black, 2012). That social engagement has been a main goal in some design attempts(Ingimundardóttir et al., 2017; Giersing, 2014; Hillman, Weilenmann, & Jungselius, 2012), while others utilize that social aspect to raise critical questions(Ryding & Løvlie, 2018).

2.2 Critical Design and Mixed Reality

Flanagan (2009) describes critical play as a form of play that happens in spaces and on activities that question aspects of the human life. Critical play occupies or creates those spaces, while those spaces are not necessarily meant for play to arise in them. Museums traditionally are not considered play environments. As they do pose questions about cultural citizenship. In society, the museums have an important role in the formation of identity, and democratic education(Bernhardt & Sattrup, 2014). Both those elements are required for the space to be occupied by critical play. To design for critical play, Flanagan (2009) proposes a design model(figure 3.1).

When applying this model, the designer is able to set the goals in order for meaningful play to arise in their interaction. Another important element of that model is that it accounts for diverse playstyles. That element suits the museums space, since the space accommodates different people with diverse motives as to why they explore the museum space. I, therefore, can incorporate that model in my design.

Benford and Giannachi (2011) describe a hybrid space to be an adjacent reality which tries to seamlessly connect one world to another. Those hybrid spaces emerge out of the relationship between perceived, conceived, lived physical, and digital spaces. Based on those descriptions, we can treat the

exhibition space, when combined with a mixed reality interaction, as a hybrid space. Each participant are being taken into journeys(Benford, Giannachi, Koleva, & Rodden, 2009) in the exhibition space.

Journeys maintain an overall sense of coherence while passing through different places, and time(Benford et al., 2009). These journeys are either prescripted, or generated by participants, and lead through experiences in that hybrid space, which(Benford & Giannachi, 2011) calls trajectories. Trajectories define routes across that space. Furthermore, they define two types of trajectories:

1. Canonical trajectories: trajectories that are perscripted and embedded into the hybrid space

2. Participant trajectories: trajectories that are defined by participants and are emergent and unpredictable

Another important element of mixed reality performances are seams. Seams are the "fabric of an experience as being sticked together of initially disjoint physical and virtual spaces using combinations of sensing and communication technologies and various computer interfaces as the threads that join them"(Benford & Giannachi, 2011). Our interest in seams lies in understanding how we can allow the interaction of the visitor with the necessary technology to not affect the overall design.

The use of ArtCodes as technology allows the usage of aesthetics for the prototype. As Ng and Shaikh (2016) mention in their publication, Artcodes are aesthetic codes, even though they have the same functionality as QR codes. In said publication, they evaluate ArtCodes as a tool that can enhance garden visiting experiences in public botanical gardens. Their publication is relevant to our project, since we aim to utilized ArtCodes in order to enhance a photography exhibition - connect the physical space with the digital collection.

2.3 Digital collections

Digital technologies revolutionized our relation to information. Their invention along with their increasing popularization in our society creates extensive possibilities on using them in the cultural heritage sectors in order to involve the public, and allow them to interact with the museum collection in creative and innovative ways. The cultural heritage sector recognize the utility those technologies have. They are able to connect society's need to maintain the museums useful, relevant, and efficient, while simultaneously designing for the future generations, through digitization, open access, and easy collection access(Wang, 2014). Being mindful of this dichotomy allow us to design for both interaction for entertainment and critical thinking, and for exposing the audience to information that is present in the digital archives of museums.

The introduction of extensive digital collections in museums is a result of those technological advancements. This introduction formed a need to connect the public with those collections. Ulrich Tarp Hansen (2014) attempts to form that connection, by using technology in the exhibition space to allow the users to interact with "The Digital Image School", a collection of education materials, that were accessible outside of the museum space. Their objective was to transfer that material into the exhibition space. This was attempted by placing touch screens within the physical museums setting. That attempt proved to be problematic due to the way the visitors perceived the technology that was utilized. The touch screens were not a transparent layer, which draw the attention away from the deeper insights available through the educational materials, and into the technology itself. That example showcases that the need to properly connect the digital collection with the exhibition space is imperative. It is not enough to form that connection, but one should be careful to not alleviate the visitor's attention from the collection and towards the technology itself.

The demand for archive digitization, in order to form digital collections, is recognized both in the museum sector, and outside of it. Projects, like the Cultural Heritage Project developed by the Danish Broadcasting Corpora-

tion, exhibit how private institutions acknowledge the important of developing those archives. A key component to that project is interactivity, which will encourage active rather than passive consumption of the museum content. It is not enough that access to data is possible, but the form that those data are available in, should afford various creative ways to be actively used(Golodnoff, 2014). When we design in order to promote a dialogue between shared cultural heritage and the general public we need to design with that interactivity in mind, since our design is for a cultural heritage institution.

2.4 Project

This research thesis is attempting to connect those 3 fields, and connect the digital collections with the visitors through mixed reality interactions and critical play. Mixed-reality technologies offer possibilities to design for creative interactions, while critical play allow that experience to be meaningful, critical and social. The visitor then is able to interact with the digital collections in a deeper level, rather than just being a passive listener.

Chapter 3

Method

This chapter focuses on the methods that were utilized to design the interaction and to develop the project. I present the design principles and methods that influenced my process, and why they were chosen. Furthermore, I will describe designing for playfulness as a practice to design and create meaningful critical interactions in the museum context.

3.1 Design

3.1.1 Designing for playfulness

A central element in my design is playfulness. Designing for playfulness is attempting to inject some of the characteristics of play into an activity that is non-playful, and engaging with the world in a playful manner but without playing(Sicart, 2014). Playfulness allows the visitors to engage with the collection in a playful manner. Playfulness is important in this context since the museum is not a space of play, but rather a space of information, cultural identity, and education. Through playfulness though, visitors can appropriate the exhibition space, allowing them to engage in a deeper level with the collection. Flanagan (2009) describes the process of designing play as the process of designing for possibilities. Games and play are becoming more and more established in our society and culture, and designing for possibilities means

having an inclusive, and fair design that visitors with different playstyles can engage with(Flanagan, 2009).

3.1.2 Trajectories Conceptual Framework

The path that a visitor follows inside a museum exhibition can be interpreted as a trajectory, since is a continuous and coherent journey through the museum space. This interpretation allows me to apply the trajectories conceptual framework(Benford & Giannachi, 2011), in order to design for the museum space. Using that framework, an exhibition can be expanded with *hybrid structures*, through the mixed reality design. Visitors traverse museums like *hybrid spaces*. They move through the physical exhibition space, and at the same time they can access the virtual space through the mixed reality interaction, connecting the different physical exhibits with the digital collection, or other physical exhibits.

During their visit, visitors alter the interaction for future visitors by affecting it with their own life experience, since they assume the role of an active participant. To accommodate for that aspect in the design, the concept of *hybrid time* can be applied. The interaction time of the visitors affect the overall timing of the events, as to what will be perceived by future visitors, and what was perceived by past visitors.

Furthermore, to design for the visitors' journeys through the exhibition, it helps to think in terms of *Participant trajectories* and *Canonical trajectories*, in order to understand and design the paths that visitors choose to take, and how the design affect the way they traverse the space.

An interesting and important aspect of the Trajectories Conceptual Framework is the various *transitions* that are defined, which maintain the sense of continuity and coherence during the experience. Those transitions have a key role when designing a mixed reality experience, and are utilized in order to arrive to the final design of that experience, by providing goals, rules and restrictions.

One can use the concept of *Beginnings* and *Endings* to frame the experi-

ence, and create an environment that helps the visitor reflect on the exhibition they witnessed. Then, the concept of *Role transitions* and *Interface transitions* is useful to understand how the design is to be communicated to the user, especially since in a museums context it is expected that the visitor has no prior experience with the software, and some times with the hardware, that they need to interact with. Digital collections exist in a different virtual space, while the exhibition exists in the physical space of the museum. To accommodate for that the design must account for the *Traversals between physical and virtual worlds* and how that is possible through traversable interfaces. In the museum context, the visitor spends more time in the physical exhibition than the digital collection. That creates an episodic nature on the visitor's interaction with the virtual space of the interaction. That *Temporal transitions between episodes* needs to be accounted for, and handled properly. *Transitions into physical resources* can prove to be problematic in a museum context, especially if visitors have to wait in order to interact with the resource. By the same principle, *Transitions across seams in the infrastructure* are equally important, since technical problems with the sensors or the wireless communications are frustrating. Expecting multiple visitors in an exhibition creates *Interleaved trajectories*. Through those trajectories, the social aspects of the experience are revealed, as well as the isolated aspects. If museums require the experiences that arise through their exhibitions to be social, and the visitors to be active participants, sharing their life experiences and altering the exhibition through their participation, then it is important to explore those trajectories, in order to understand the patterns of social interaction and isolation that a mixed reality interaction creates.

3.1.3 Critical Play method

After elaborating as to why designing for playfulness is a meaningful practice, Flanagan (2009), proposes her appraised iterative design method to be used to develop projects that contain elements of critical play(figure 3.1).

That method is divided into 7 steps. During the first step, the designer

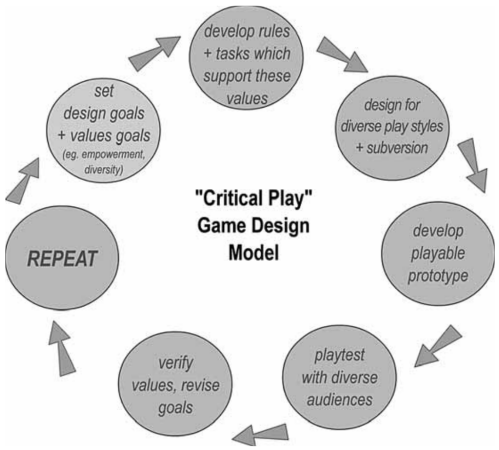

Figure 3.1: Critical Play design model(Flanagan, 2009)

sets the design goals, through which meaningful play will arise. Then, for the second step, rules and constraints need to be developed. Those rules serve as a framework for play, supporting the critical values of the design. The third step for the designer is to design for different play styles, allowing the player to appropriate and subvert the system in order for play to arise.

After those design steps, as a fourth step, a playable prototype is developed. Next, as a fifth step, playtests are conducted, with diverse audiences as testers, in order to examine how different types of players interact with the design. Then, based on the outcome of the testing, as the sixth step, the designers need to evaluate their playful design, by verifying if the value goals arise through interacting with the design, and if the experience was engaging. The final seventh step is to repeat the cycle with the new knowledge that the designers discovered through the previous cycle.

That iterative process is the process that I applied to develop a design in order to answer my research question. The main reasons I utilized this method are its focus on the inclusiveness of diverse audience, and on meaningful design goals. In a museum setting, a diverse audience is expected, and as I established before, that audience expects meaningful interaction with the museum space, rather than just play for the sake of playing.

3.2 Evaluation

The following section presents the methods that were applied in order to evaluate the success of the design and gain insight on what findings were produced through the design to the research question.

3.2.1 Research in the wild

Research in the wild(Benford & Giannachi, 2011) is a methodology that was developted by the *Mixed Reality Laboratory*. It is being used to analyze projects in the Mixed Reality field. The process is composed by three main characteristics:

Led by artistic practice:
This method has been applied to projects that are either developed by professional artists, or they had a high degree of artistic freedom during their development process.

Ethnographic studies:
After the development of those projects, their public performances will be studied. Video, interviews, and system logs of those performances would be captured, along with any type of documentary material.

Abstracting theory:
Finally, abstraction of theory is conducted, by analyzing the documentary material from the previous step.

To sum up, the approach consists of *Practice*, *Studies*, and *Theory*(figure 3.2), and it was selected, since during the project of this thesis, due to the nature of playfulness, I had artistic freedom during the process.

3.2.2 Phenomenological Interviews

To evaluate the results of the playtests, a set of interviews were conducted in order to gather qualitative data regarding the experience. To conduct those

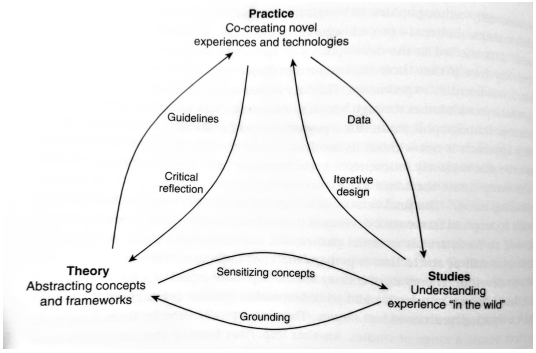

Figure 3.2: Relating practice, studies, and theory(Benford & Giannachi, 2011)

interviews, I utilized the method of phenomenological interviewing presented by Bevan (2014). Contextualizing the experience is well connected with the "Critical Play" Game Design method, since it allows us to evaluate how the different play styles of the users affect the experience. In addition, that method, permits the use of a semi-structured interview, which is affected by the context and the experience of the candidate.

Chapter 4

Results

4.1 The Keld Helmer-Petersen exhibition

Keld Helmer-Petersen was a danish photographer that was born on 1920 and passed away on 2013. His life work contains more than 16000 photographs. This archive of analog photography has been digitized and is accessible through the digital collection of the *National Museums of Photography*. His works consists of a variety of photographs, with the main focus of his life work being abstract colour photography.

The *National Museum of Photography* is planning on exhibiting a part of his work in the physical space of the museum. The exhibition is scheduled to be open to the public in Spring 2019. Inside that exhibition, the visitors will have the chance to observe analog photographs of his work. The physical space, due to its limits, is not able to accommodate *Keld Helmer-Petersen*'s whole life work. Therefore, for the visitors to have a holistic view of his oeuvre, they have to explore the digital collection along with the exhibition.

To answer the research question, this exhibition is used as an ideal model. The reasoning behind that decision was the extensive life work of the artist, as well as, the fact that his lifework is already digitized and freely available. The public is able to access the digital collection of the museum through the Internet, and observe the photographs of the artist.

4.2 Design Objectives

As the first step of applying the Critical Play game design model(figure 3.1) is to set our design and values objectives. In this section I present which goals my design has and the reason why they affected the design process.

I arrived to the following goals both through researching past projects that are in the same field, and by conducting expert interviews. The *National Museum of Photography* had specific requests for various aspects of my design which they communicated to me. Ultimately, the interaction focuses on their exhibition and their museum space, thus I respected those requests. They are experts in their field and their opinion is of great value.

4.2.1 Exposure to the digital collection

The first and most important goal is to expose the visitors to the digital collection of the museum. This objective is a result of the research question of this thesis. Moreover, this is imperative for the success of the interaction. Ultimately, the goal of this process is to further understand how one can create exposure to the digital collection, and discover the elements that can create such exposure in a successful way.

4.2.2 Aesthetics

One important constraint set by the *National Museum of Photography* is that in order to display any object in their museum space, it needs to be aesthetically non-intrusive. That eliminates the possibility of displaying QR codes, Barcodes, or anything similar in the museum space. This constrain is expected, especially from a spaces that have art exhibits, where aesthetics have an important role in the way the space is organized.

4.2.3 Minimalistic Design

Following the previous constraint, to create non-intrusive objects and interfaces, minimalism is key. It is necessary to have minimalistic design for the interaction, since the interface to be intuitive and easy to communicate to the visitor, and at the simultaneously it is important that the visitor focuses on the exhibits rather than the interaction. The interaction needs to be supplementary to the exhibition, rather than having the leading role during the visit.

4.2.4 Ludic Elements

Sicart (2014) mentions the merits of playfulness, and how appropriation affects how data are explored, and how new knowledge is revealed. That appropriation opens the way for personalization, which is an important element for the museum of the twenty-first century(Black, 2012). Through the interaction with the ludic elements of the design, the visitors become active participants of the collection instead of just passive listeners. They choose how to navigate that collection, giving them the opportunity to explore it in their own terms, and set their own goals.

4.2.5 Social Elements

A final goal is to utilize the appropriation the visitors have over the interaction and the collection, in order to shape how other visitors perceive that collection and interact with it. The visitor then, as an active participant, shapes the future of that collection, and their life experiences are stored for other visitors to discover(Black, 2012). In order to achieve that, the interaction needs to facilitate those social actions between the visitors, in an critical format.

4.3 Prototyping

During the development cycle of this thesis I developed three prototypes, one for each iteration of the "Critical Play" game design model. This section is dedicated on analyzing those iterations, their products, and the technologies behind those products.

4.3.1 ArtCodes

A fundamental technology that is employed in all three prototypes is Artcodes. Artcodes are visual codes that can be scanned by using a mobile device and can take the shape of decorative patters that are aesthetically pleasing to people(Benford et al., 2013). Artcodes provide the freedom to create codes with a minimalistic and aesthetically pleasing form, allowing them to be displayed into the museum space. In addition, they act as a prototype tool, since it is an already established technology with a stable framework that is easy to use in order to create create and scan the codes. Those were the two reasons why Artcodes was chosen as the scanning tool for my prototypes.

The software itself is open-source, and the visitors are able to download it for free through Google Play and the App Store. Then, once they download the application, they need to open it and download the specific *Experience*, which will then allow them to scan the codes. When a code is scanned the app will return a hyperlink which the visitor can then click and they will then be transfered to the interaction(figure 4.1).

The codes in Artcodes consist of regions, a boundary and blobs. The boundary ensures that all regions are connected together to form the code. The regions are enclosed spaces that are connected through the boundary. They can have any shape as long as they are enclosed. Inside those regions there are the blobs, which are solid shapes. The Artcode is formed by counting how many blobs are there in a region, then that region's digit is the number of blobs that it contains. Once all the digit corresponding to the regions have been counted, the Artcode of that shape is formed by placing all the digits in

Figure 4.1: ArtCodes application, hyperlink

ascending order with colons between them.

4.3.2 First Iteration

The first prototype consists of a wordpress website, a MySQL database to store the data provided by the visitors, and the Artcodes software. Wordpress was utilized for prototyping purposes, since it already contains the functionality of posting pictures, and a commenting system. In addition, there is an add-on that is implemented that facilitates the intergration of Artcodes in wordpress.

Each photograph is assigned a unique artcode, and a question, starting from

1:1:1:1:1 - only 5 numbers are needed since the number of total photographs has 5 digits. The representation of the code 1:1:2:3:5 is as shown in figure 4.2. That representation was chosen due to its non-intrusive and minimalistic design. When a visitor enters the exhibition, they are be handed a booklet which contains a number of random codes - for the purposes of the prototype, the arbitrary number ten was used. In every page there is a code, and in every code there is a question that needs to be answered, the title of the photograph that the Artcode corresponds to, and the Artcode itself(figure 4.3).

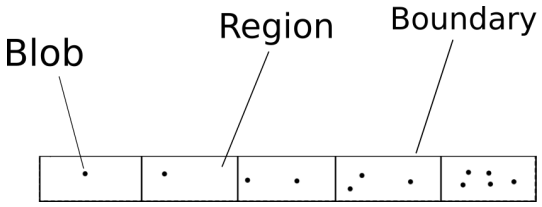

Figure 4.2: ArtCode explanation

The page itself is not scannable yet, because in order for the Artcodes to be scanned there must be scannable regions. To create those regions, in the end of the exhibition there are some picture frames(figure 4.4). The visitor can use these frames to make the page scannable. To do so, the visitor needs to tear off the page from the booklet and insert it into the frame - connecting the vertical dotted lines with the arrows shown on the frame. Then the Artcode on the bottom of the page is separated into regions and is scannable.

Now, the visitor is able to use the Artcodes application to scan the page, which will produce the link to the web application. By clicking the link, the visitor gets access to the webpage of the photograph, there they can see the photograph, and reflect on it. The web application then prompts the visitor to answer the question. Once they answer then they will be redirected to a page that contains another visitor's anonymous answer to the same question.

Goals

As their primary goals, all the prototypes that are presented in this section, they have to expose the visitor to the digital collection. That being said,

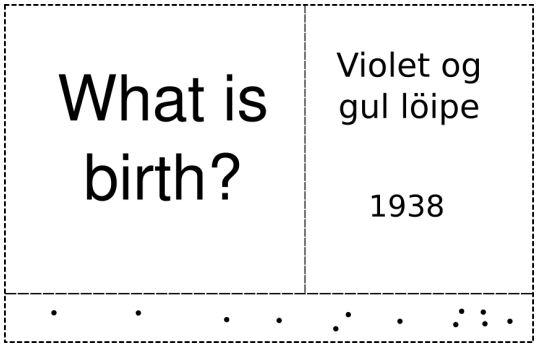

Figure 4.3: Prototype 1, booklet codes

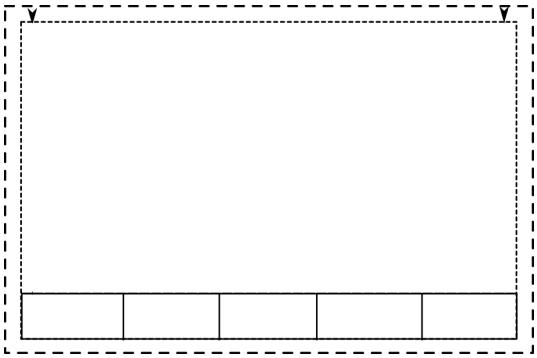

Figure 4.4: Prototype 1, frame

during the first iteration, focus was given primarily to the social aspect, in par with the primary goal. The objective was to provide the visitors with a platform that would facilitate the communication with each other. That social platform would allow the visitors to actively engage with the collection, and share their life experiences with the rest of the visitors. In that context, the art pieces - both the physically present, and the ones found in the digital collection - serve as an inspiration for the visitors to retrieve their memories, their personal stories, and life experiences, which then will share with each other. Those served as primary "values" goals and design goals(figure 3.1) for the first iteration.

Rules

In order for the design to work the visitors need to share personal experiences. To inspire the visitors to share their personal experience , the page contains a question which they can answer. That question is relevant to the artwork, and at the same time is open-ended in order to create a discussion topic, were personal stories can be shared. To create a cycle of sharing, a visitor needs to share their answer to the question - anonymously - and then they will be presented with an answer provided by another visitor. This serves as a mechanic(Sicart, 2008) that sustains the insertion of content in the interaction, and it ensures the fact that the visitor commits to the interaction. This mechanic supports the value of social meaningful interaction, through the sharing of personal experiences. Furthermore, the visitor, through that cycle, is exposed to the digital collection, since when they scan the code they observe an image from the digital collection, which they will have to reflect on in order to answer the question that is given. The way the codes are scanned - tearing the paper and inserting it into the frames that are in the museum space - forces the interaction to take place in the museum space, a space that is about art, culture, and reflection. In addition, the action of tearing the paper off is satisfactory to the visitor.

Diverse Play styles

The aforementioned rules allow diverse play styles and subversion to arise through the interaction. In addition to the already described play style - the canonical trajectory of the experience - a visitor may also attempt to draw the codes themselves, instead of tearing the paper, thus being able to preserve the booklet after their departure from the exhibition, thus maintaining the possibility of scanning the pages and accessing the digital collection on their own. That creativity is afforded by the paper as a material, since the visitor can appropriate the booklet, and freely draw on it.

4.3.3 Second Iteration

After completing the first iteration I consulted my supervisor Anders Sundnes Løvlie, an expert in the field of museum interactions. During that consultation he mentioned that during his publication with Karin Ryding they discovered that one important criticism about their design was that it was not connected with the exhibits that were displayed in the *Museum of Yugoslavia*(Ryding & Løvlie, 2018). He also commented on the fact that the way visitors are prompted to share their experiences - through profound questions - along with the fact that those questions have long answers, creates two concerns.

Firstly, the amount of commitment required from the visitor in order to answers those questions, may result in the interaction disengaging the visitor from the exhibition itself. In addition, it could result into users writing random text just so they can read the answers provided by other visitors.

Secondly, the way the previous prototype functions, is similar to the way online social sharing platforms operate, and visitors are able to use those platforms daily. In order to capture the attention of a museum visitor, the experience needs to contain elements that differentiate it from what the visitor experience in their everyday life.

Using those reflections, I started the second iteration of the "Critical Play" Game Design method.

Prototype

For the second iteration I decided to utilize different technologies. The social aspect of the design shifted from being a story-sharing platform through posts, to a minimalistic sharing of emotions. Due to that change, it was difficult to adapt the *Wordpress* framework to the needs of the new design. The second prototype was developed in the *Python* programming language, more specific in the *Flask* framework. For storing the data of the photographs and the answers provided by the visitors, an *SQL* database was created with the *SQLite3* technology which was then connected to with the *Flask* website. Finally, the design of the website was implemented with the use of *HTML*,*CSS*,

and *Javascript*.

For the purposes of the second prototype, the representation of the Artcodes did not change, along with how the Artcodes were assigned to the photographs. The second prototype still uses the 5 digit representation, with the blobs being the Artcode's dots. The same Artcode design was maintained since the comments did not refer to the design of the Artcode, neither did the design interfere with the parts of the interactions that are changed.

Moreover, the booklet remains an object in the new design, through which the visitors have access to the codes. The new design contains the interaction loop with the visitor having to tear of the pages and insert them into the frame, that was present in the old design. However, the design of the booklet pages changed. The questions were removed. The objects that remained present were the title of the photograph along with its date and the Artcode that corresponds to the photograph. In addition to the changes that were introduced to the pages of the booklet, the content itself has changed. Instead of codes to random photographs from the digital collection, visitors now receive codes to the photographs that are in the exhibition.

Another change to the first prototype was the web interface itself. The interaction loop remained the same; the visitor has to scan the code, click the link, and through that they enter the website. However, the web interface of the prototype was redesigned. When the visitor interacts with the link that is presented through the ArtCodes application, they access the interaction. The first segment of the interaction consists of the photograph, along with its title and the year that the Keld-Helmer Petersen captured that photograph. Underneath the title and year, there is a form, inside which the visitor is asked to enter a word that answers the question "what does this photograph make you feel?". Once they submit that word, the visitors are presented with the second segment of the interaction. During that, the photograph, along with its title and year, remain unchanged. Below them, however, the visitor is presented with information regarding the words other visitors have submitted to that photograph. This information is presented in the form of words. More specific, every second, the algorithm selects at random a submitted word that

is in the database. After selecting that word, it displays it to the visitor, before repeating that process again after one second. Furthermore, another feature was added to the web application. Using the answer of the visitor, the algorithm searches the database for the photographs that are described - by other users - with the same word, and have not been commented by the visitor. After creating that list of photographs, the algorithm randomly chooses four of them - or all of them if they are less than four. Then the algorithm displays those photographs in the end of the page. The visitor can select any of them and that will begin again the interaction loop that was just described, with the selected photograph this time. In case there are zero photographs that are related to visitor's word, then the algorithm chooses a random photographs from that database that the visitor has not commented on yet. The visitor can repeat this interaction for all the photographs they have not commented yet, or until they close the interface. They can restart the interaction by scanning the same code or another code from the booklet.

Goals

This new direction that the second prototype has, still has as a primary goal to expose the visitors to the digital collection. However, the focus now is shifted more towards the exhibition itself. Due to the comments the first iteration received, the second prototype attempts to bridge the gap between the interaction and the exhibition.

Moreover, the second prototype focuses less on the social aspect - while still containing social elements. That goal was revised, to explore different ways of social interaction between visitors.

The interaction needs to be more minimalistic for the visitor to be able to spend more time exploring the digital collection in a playful way, and less time reading and writing answers.

Finally, some of the answers given by the visitors are expected to be uninteresting, or even spam, and the design needs to accommodate for that.

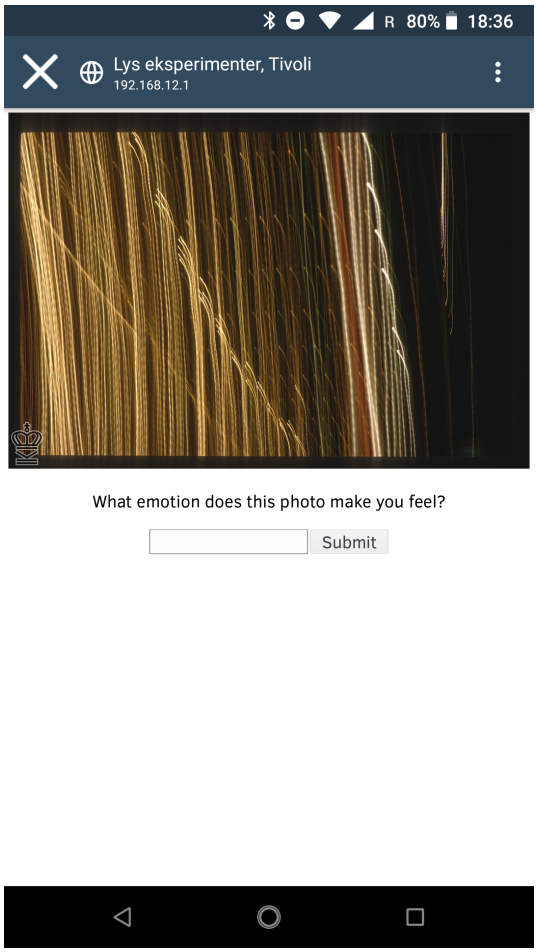

Figure 4.5: First screen of the web application

Rules and Mechanics

Regarding the exposure to the digital collection, the design displays the suggested photographs on the second part of the interaction. Those photographs are from the digital collection. The design utilizes the photographs of the exhibition as an entry point to the digital collection. This connects the physical exhibition with the digital collection.

In the interaction, the visitor is prompted to comment a single word instead of a whole experience. That direction was favored, since it allows the visitor to complete the interaction loop quicker, therefore allowing that visitor to interact

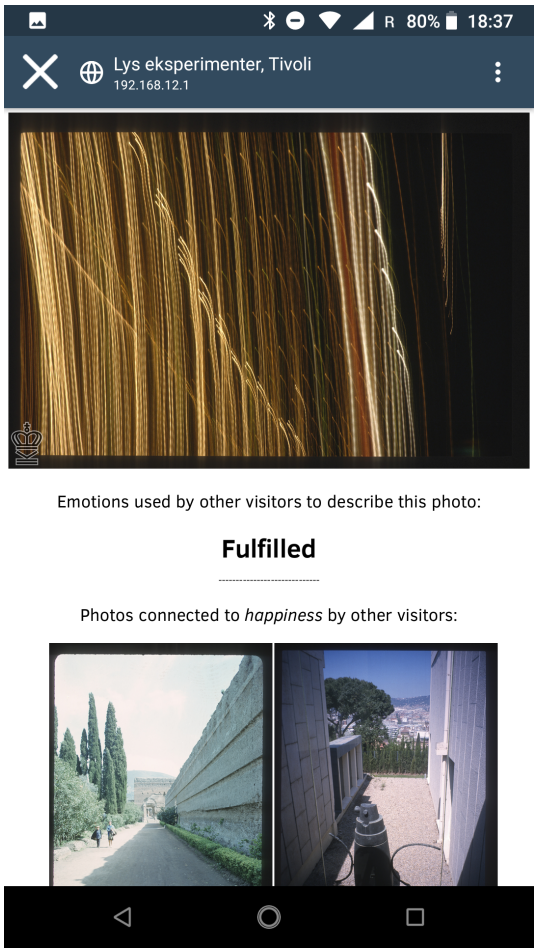

Figure 4.6: Second screen of the web application - the emotion changes every second

with more photographs. In addition, there is less effort on thinking and writing an answer, which allows the visitor to commit as much time as they want into deciding what answer they want to give. Superficial answers is equally valuable for the system as a profound one, since it is only a word. The other visitors have no way of knowing if the answers they read are superficial or not - with some exceptions. Another reason, that a single word was prefered, is that the experience becomes meaningful both through the self-reflection towards the art - which is necessary in order to answer the question - and through reflecting on other visitors' answers, which provide new perspectives on the art pieces.

Figure 4.7: Third screen of the web application - related photographs

By having only one word as the input, the design is able to display multiple answers - through the refreshing mechanic that was described - facilitating the interaction with multiple other visitors rather than just one. Furthermore, by allowing the algorithm to display different answers every second, spam answers become less problematic since they change after a second.

Related photographs were added in the interaction to allow the visitors to endlessly explore the digital collection. To create that endless loop, in case the visitor submits a emotion that has not been submitted before, the algorithm will choose a random photograph as related, in order to keep the loop possible.

Diverse Play styles

The possibilities for diverse play styles due to the affordances(Norman, 2013) of paper that were described in the previous prototype are still valid. In addition to those, the fact that the visitors can spend a variable amount of time to reflect on which answer they want to provide to the system, allows both casual visitors that just want to explore the collection, and visitors that want to deeply reflect on their answers, to experience the interaction in their own way. The same principle applies to the visitors as to how much time they desire to spend reading the answers provided by other visitors.

4.3.4 Third Iteration

That second prototype was presented to the team of the National Museum of Photography who is responsible for the *Keld-Helmer Petersen* exhibition, in order to receive feedback, and discover whether or not the interaction fulfills the goals set for the exhibition, and if it is befitting to the character of the exhibition.

Through that meeting, a beneficial discussion was conducted, regarding the direction of the prototype about which parts should remain as is, and which parts should be altered, in the interest of including the interaction in the exhibition.

One of the first requests they had was to remove the booklet completely. Instead, they suggested, the labels that the visitors scan should be on the wall next to the photographs(figure 4.8). Although the museum is reluctant to have scannable codes on its wall, they accepted the ArtCodes design that I used due to its minimalistic and non-intrusive qualities. They were especially interested with the ArtCodes as a technology due to its freedom regarding the design of the codes.

Regarding the web application, they appreciated the simplicity of the interaction loop. Their appreciation is based on the fact that due to its simplicity, the interaction will not draw the attention away from the exhibition, rather it will enhance the exhibition. Thus, one of their requests was to not complicate

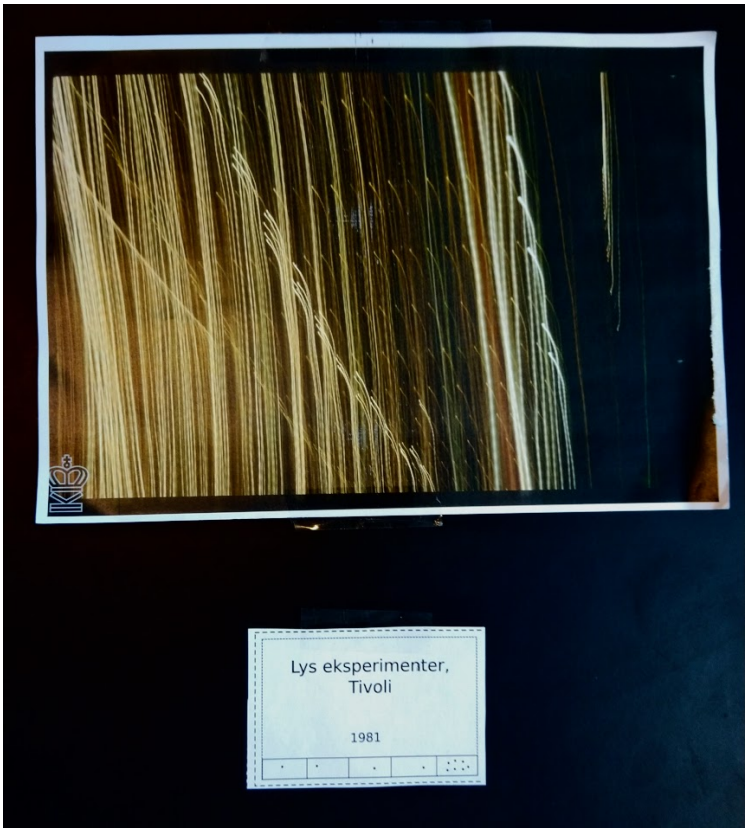

Figure 4.8: Exhibition example: photograph with label

further the interaction loop.

They commended the design decision to use the sharing of emotions as the social aspect of the interaction. They agreed that, by using emotion, it is possible for everyone to participate in that social exchange, regardless of their individual knowledge about art. Emotions are personal, and are related to life experience, thus there is no wrong or right answer. That inclusiveness to all social groups is what this interaction adds to the exhibition. In addition to admiring those exhibits for their artistic qualities, asking a visitor about their emotions can create a personal connection with the exhibits and with the rest of the visitors. They agreed that using emotional responses works with abstract photography, due to the open interpretation of the photographs by the visitors. However, they added that the direction of the prototype should move towards

a curated digital collection - which they are willing to curate. A curated digital collection would contain abstract work from *Keld-Helmer Petersen*, instead of his whole lifework that contains also non-abstract pictures. They are more interested in exposing the visitors to those abstract photographs rather than his whole works.

After that discussion, the third and final iteration of the prototype was implemented.

Prototype

With respect to the comments that the exhibition's professionals had, the web application remained unchanged. Under the same principle, the design of the scannable labels remained the same - the title, the year, and the ArtCode, with one slight change. The ArtCodes on the bottom of the label are created to be scannable, without the need for the frame. That change came because the frames are removed from the new prototype, since now the scannable labels are on the wall, next to the photographs. That means that there is no booklet in the new design. The visitor needs only to download the ArtCodes application, which they can use to scan the labels of the photographs.

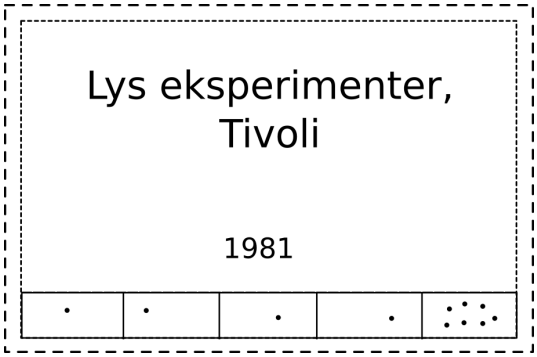

Figure 4.9: Final design of scannable labels

Goals

For the final iteration, the previous goals remained the same, since the exhibition team mostly agreed with the overall design goals, and the decisions that

were made during the design process.

However, the goal of connecting the interaction with the exhibition, needed to be revisited. The museum's professionals requested that the interaction to enhance the exhibition, and for that to happen the interaction must be used by the visitors while they are exploring the exhibition rather than by the end of their visit.

Rules and Mechanics

To connect the visitor more with the exhibition, the booklet was removed - per request from the museum - and the scannable labels are now next to the photographs. This rule was explored in the past but was rejected since museums tend to be cautious about what they display on their walls. However, in this case, the experts themselves suggested it. Now there is a direct connection with the interaction and the exhibition, since the visitors use the exhibition itself as an entry point to the digital collection.

Diverse Play styles

Even though the paper as a material was removed, visitors can still appropriate their reflection time on the photographs as mentioned in the previous prototype.

Moreover, the new prototype allows the visitors to appropriate the exhibition space. Inside the digital collection, the photos that are present in the exhibition can also be found. This creates a playful environment that subverts the exhibition space, since visitors can use the interaction as an exhibition guide.

4.4 Trajectories Conceptual Framework

In this section I will present the connection between the framework and the final design.

Beginning:

That is the entrance to the exhibition. Once the visitor has access to the ArtCodes application and they are informed about the scannable labels, the experience is framed, and those labels are not just physical objects anymore, but also connections to the virtual space.

Ending:

That is the exit of the exhibition. By exiting, the visitors lose access to the scannable labels, rending the interaction inaccessible. However, the visitors have left their submissions in the database, and therefore they share their memories indirectly with the future visitors.

Traversals between physical and virtual worlds:

The ArtCodes application facilitates the traversal between the physical world - labels and exhibition - to the virtual world - web application and digital collection.

Temporal transitions between episodes:

The labels themselves create the temporal episodes with which the visitor can interact.

Interleaved trajectories:

The encounters that lead to interleaved trajectories between the visitors happen when a visitor reads the emotions that have submitted in the past.

4.5 Playtests

For the first two iteration of the "Critical Play" Game Design method, the last two steps of the method - playtest and evaluation - were conducted by presenting the interaction to experts, and discussing with them the desicions that were made through the process. By receiving the feedback from the experts, I was able to refactor my design using their experience and expertise.

For the final iteration, it was necessary to test the values and goals of the design in practice, thus a round of playtests was organized. The idea was to simulate the museum space, find some visitors, and observe how they interact with the design in that space.

4.5.1 The Model Exhibition

To create the museum, I occupied one of the rooms of the university, inside of which I created a small version of the *Keld-Helmer Petersen*'s exhibition. The exhibition consisted of eight photographs - printed from the museum's digital collection - and their respective scannable labels. All eight photographs with their scannable labels were glued on the wall to simulate how they will be displayed on the final exhibition.

Once the environment was arranged, the eight candidates were invited one by one to participate on the playtest. The playtest was divided into two segments. During the first segment, the candidate was instructed on how to download the application, and how to open the proper *experience* in the ArtCodes application. After the technical instructions, the candidate was told that "This is an exhibition space. It is a complete exhibition space, there is nothing more in the exhibition than these eight photographs. You can interact with the photographs by using the application." - at which point the candidate was free to interact with the space in any way they desired, without any time limit. The reason that the candidate was assisted in downloading and setting up the application is that it was not deemed necessary to test that aspect of the interaction, since in the museum there will be assistance for people if they need so, and also this technical procedures before the actual interaction are not of interest for this thesis. The candidates, however, were not provided with any instructions as to what is scannable and how to scan an object, since it is important to test how seamlessly(Benford & Giannachi, 2011) is the interaction perceived.

4.5.2 Interview Structure

Following the interaction with the space and the application, the second segment of the playtest was an semi-structured interview, in order to evaluate what did the visitor experience, and how the interaction was perceived. The general structure of the interview consists of the following questions:

1. Can you describe to me your relationship with museums?
2. What about your relationship with photography and art?
3. Describe to me what you experienced while using this interaction.
4. Did you notice the photographs displayed on the bottom the web application?
5. What do you think those photographs were?
6. Describe to me how this interaction has affected your museum experience.
7. Did it affected the way you perceive the photographs?
8. How was your experience of using the interaction?
9. How was your focus divided between the exhibition and the interaction?
10. Did the interaction felt connected to exhibition?
11. How was your interaction with the ArtCodes interface?
12. Do you have any comments regarding the design of the web application?
13. Any last comments?

Questions *1* and *2* were used to establish that a diverse audience is utilized for the playtest, since that is required by the "Critical Play" Game Design method. It was also important to contextualize the experience(Bevan, 2014) to understand how it was perceived by the candidates.

Questions *3*, *4*, and *5* were used to determine the level of the candidate's understanding regarding what they experienced, and what were the specific elements of the interaction.

Finally, the rest of the questions were used to apprehend(Bevan, 2014) the phenomenon. I was especially interested into how the interaction affected the candidate's reflection towards the art pieces and their emotional response towards the art. Furthermore, a number of those questions - *question 6*, *question 9*, and *question 10* - were selected to evaluate whether or not the interaction managed to fulfill the goals that were set. Although, all of the aforementioned questions were asked during each interview, the interview was semi-structured, therefore in the end more questions were included during my conversations with the candidates.

4.5.3 Test results & Candidates

Regarding the selection of candidates, all the six candidates are Master students.

In general, the candidates figured out with ease how interact with the ArtCodes interface, and that the labels are scannable. Although most of them were not certain regarding which part the application was scanning, they did not face any difficulties regarding scanning them.

Furthermore, most of the candidates comprehended the elements of the web application - both the initial form, and after what the emotions and the related photographs were.

All but one candidate wanted to be informed when a random photograph was suggested to them.

In the following segment, I will describe the importart events that transpired during each playtest.

Candidate A

The first candidate - Adam - after submitting the first emotion, upon being presented with a related photograph, he searched for the photograph in the

exhibition. The photograph was not there since it was from the digital collection. That interested into finding the photograph in the exhibition is an example of playful behavior. Visitors can use the application as an alternative way to traverse the exhibition space.

Adam commented that reading the emotions of other visitors made him reflect on the fact that people see the photographs differently.

Candidate B

The second candidate - Britney - wondered if she could write more than one words in the form. She felt disconnected emotionaly with the suggestions. This is justified, since most of the suggestions she had were random.

She commented that she would prefer to had the title being displayed on the ArtCodes application instead of the URL. She found more exciting when the photographs she was suggested were in the exhibition, rather than the ones that were on the digital collection.

Candidate C

The third candidate - Charlie - was focused on the suggestions, and displayed zero interest towards other visitors' comments regarding the photographs. That is another example of how the visitor is able to appropriate the experience to fit their personal goals.

Furthermore, when he is thinking what emotion to submit, he is looking at the physical photo rather than the phone screen.

Candidate D

The fourth candidate - Dan - displayed strongly his disagreement with the emotions that have been submitted by other visitors. By having to think of an emotion, he said, the interaction help him reflect about his feelings towards the photographs.

He was the only candidate that did not understand that he is able to interact with the related pictures by touching them, thus he never restarted

the interaction loop through the web application.

He suggested a ranking system for the photographs, similar to the ones social networks have.

Candidate E

The fifth candidate - Earl - had a habit of switching from horizontal to vertical view depending on the orientation of the photograph. He also commented that he didn't like the small size of the photographs.

Along with Dan, Earl was the second candidate that requested the option of being able to "like" the photograph. He also wanted to be informed whether or not the photograph is present in the exhibition, or just in the digital collection.

He appropriated the interaction by deciding to trying to predict what is the most common emotion the other visitors have used to describe the photographs, rather than sharing his own emotions. He perceived that prediction as a game, and he wanted to be rewarded when he was correct in his prediction.

Finally, he wanted to be able to click on the emotions that were displayed and see what photographs are connected to those emotions.

Candidate F

The sixth and final candidate - Frank - wanted the whole interaction to be more efficient, with less steps between scanning and accessing the web application. He also felt that he spent too much time on his screen compared to the exhibition.

He said that the interaction made him connect deeply with the photograph, exploring his feelings in depth, spending time thinking and reflecting on what the photograph means to him. He didn't find important or interesting to read the other visitors' comments or open the related photographs. For him the experience was personal, and he only focused on the aspect of the reflection.

One important comment he had was that even though he enjoyed his first interactions with the application, he wasn't sure that he would continue using it if the exhibition was larger.

Finally, he was the only candidate that prefers the application to lie to him regarding the random photos.

Chapter 5

Discussion

In this chapter I will discuss the results of the playtests, and address how they connect to the original goals that were set by my research and through the discussions with the experts.

5.1 Play test evaluation

The second step of the "Research in the wild" method(Benford & Giannachi, 2011) - the studies - was conducted by setting up the model exhibition presented in the previous chapter. The objective was to simulate the museum environment in a controlled space and observe how the visitors interact with the mixed reality interaction. Ideally, that environment would be the *Keld-Helmer Petersen*'s exhibition itself. However, that is a future exhibition which is not installed yet in the museum space. This problem is expected to appear when designing for future temporary exhibitions, since each design iteration could last for a significant time period, therefore testing will have to be conducted before the exhibition is installed in the museum space.

To address that, the model exhibition was set up. That model is significantly smaller than the exhibition itself. With that in mind, one needs to be cautious with any results that are related to the spatial aspect of the exhibition - e.g. when candidate Frank mentioned that he doesn't know if he would use the interaction if the exhibition was larger - or the amount of time a visitor

would use the interaction. Those aspects require further testing in a different environment, ideally in the exhibition environment.

Furthermore, any results that are related to the specific content of the physical exhibition are also difficult to analyze, since the content of the physical exhibition is unknown, and that model exhibition cannot simulate that.

The model exhibition is useful to simulate other aspects of the exhibition. It can operate as a vertical slice to the exhibition, allowing the analysis of the interaction loop for a single photograph. By removing the temporal and spatial element of the exhibition, the core interaction can be observed, and how did the visitors perceived the interaction and its elements. In other words, the model exhibition is successful in revealing the instant and short-term effects of the interaction to the visitors, but unsuccessful in revealing the long-term ones.

5.2 Objective Evaluation

When formulating my design, there were specific objectives that were set. Those objectives are the combined result of what has been researched in the literature I reviewed, what the experts suggested, and the specific needs of the exhibition. Those objectives were the result of my research as to how to design such an interaction. In this section, I will discuss in detail what the data collected reveal about the interaction.

5.2.1 Exposure to the digital collection

The main objective of the design was to answer the research question of this thesis. Was the visitor, through their interaction with the prototype, exposed to the digital collection of the museum? Through the user tests, it was observed that all participants were exposed to the digital collection. By interacting with the web application, all candidates acknowledged the related photographs, which belong to the digital collection.

Even though the visitors were exposed to the collection, that was not what

they focused during the design. They displayed little to no interest regarding the digital collection. On the contrary, they spent time reflecting on the photographs, either by contemplating about the emotion they want to submit, or by analyzing the emotions other visitors have submitted. The interaction proved to be more a reflective, social experience than a playful way to navigate the digital collection.

Playfulness exists when visitors are able to appropriate, and subvert the space they are in(Sicart, 2014), and in the interaction that appropriation exists in the emotion choice, since that is the part were the visitors have agency on. They invest by sharing a personal answer, which then makes that part of the interaction the focus of the visitors. This realization changes the main objective of the interaction to be about facilitating a meaningful communication between the visitors, opening a conversation between them that is about reflaction towards emotions and art.

Ultimately, the playtests revealed an important aspect that requires further analysis. Although the visitors were exposed to the photographs of the digital collection, this whole interaction requires the visitor to be focused on their mobile device. This removes their focus from the exhibition. Some users commented on the fact that they didn't appreciate that they had to stare at their devices. The interaction itself was designed with minimizing the amount a user is required to spend on their device. Therefore, that raises the question for further research: *Is it possible to design for a mixed reality experience that blends the digital and the physical space in a seamless way?* Benford and Giannachi (2011) describe the fabric of an experience to be stitched together from different parts. The more those parts become visible the less seamless the experience becomes. However in their book they focus on projects that users request participation. That is not the case for a museum visitor, where the museum itself needs to attract the visitors to use their mixed reality interaction. When attempting to hide those seams, we need to further understand what the visitors perceive as seams in their museum experience. In our case, those seams are the mobile phone itself, along with the technologies that are required to scan the codes, and the Internet connection, and in case exposure to the digital

collection is a goal, further research needs to be conducted in order to discover if and how that objective be achieved through enhancing the exhibition, rather than taking the focus away from the exhibition.

5.2.2 Aesthetic Codes

One important objective was that the codes need to be non-intrusive and minimalistic. This was requested by the designer that is responsible for the *Keld-Helmen Petersen* exhibition. The design of the codes must not be intrusive, and simultaneously it had to be intuitive for the visitor to scan. This objective was especially imporant, since the museum would otherwise be reluctant in accepting the design to be included in the exhibition.

During the playtests, the visitors scanned the tags with ease, without specific instructions on how to do so. In addition, none of them - with the exception of the expert tester - recognized which part of the tag is the ArtCode and which is just information regarding the picture. This validates our objective that the codes need to be discreet and intuitive.

When the museum's team was presented with the codes, they were satisfied with the ArtCodes appearance, and agreed to display them in the exhibition space.

Access to the web application is given through the ArtCodes application, by scanning the codes. ArtCodes is an excellent prototyping tool, and that was one of the main reason that it was utilized. The same functionality could be achieved by using image recognition software, potentially eliminating the need for scannable labels on the museum walls. In my design, I utilized ArtCodes because it bridges the gap between image recognition software and qr codes, the first being error prone, while the second having an intrusive design - i.e. drawing attention to it inside the exhibition space. *Keld-Helmer Petersen*'s lifework contains old analog photographs that are preserved, with some of them are already decaying. That damage along with the unpredictable lightning of the exhibition space, made the ArtCodes less error-prone, thus a safer choice.

5.2.3 Minimalistic Design

When designing the interaction loop of the design, along with the interface of the prototype, one of the objective was for it to remain minimalistic and simple, both in terms of aesthetics and in terms of affordances(Norman, 2013). The museums experts requested simplicity in the design. Thus, the design - on its visual interaface - allows for only one possible action at any given moment.

The design proved itself to be intuitive and simple. During the playtests most of the visitors had no problems understanding its elements. All of the participants, when asked how they perceived the design, found it simple and non-intrusive to the whole experience. In addition, the museum experts approved the design, and requested that it remains as simple as it was when presented to them.

That minimalism allowed the visitors to immediately understand what the interaction is about and how to interact with the interfaces. Having an minimalistic interaction, allows the visitors to not lose focus towards the exhibition by trying to understand how that interaction works. Maintaining that focus to the exhibition is what gave the visitors time to reflect on the experience, and to connect to the experience immediately.

5.2.4 Ludic Elements

During the playtests, participants discover various ways to appropriate the interaction and the space. They set their own goals as to what that design means to them. They used the related photographs as an alternative way to traverse the exhibition - like a treasure hunt. Others challenged themselves to predict what the other visitors have commented. The interaction allows the visitors to appropriate it's design by setting their own personal goals, and through that they can subvert the database of emotion and the application, thus playfully engaging with the space and the exhibition.

Through critical play the visitors can have meaningful reflective experiences when interacting with the museum space. The elements of appropriation and subversion shape the environment for those experiences to arise. However, it is

important to consider the space inside which that play happens. Museums are spaces of cultural heritage and there are limits on the types of playfulness that is accepted inside those spaces - depending of the museum. Those limits are constraints on the final design. It is important to contextualize that subversion, and allow for it to happen on elements that are important - emotions in our case - and simultaneously protect other elements - physical interaction with the photographs, yelling, etc. - that could be opposed to the character of the museum.

5.2.5 Social Elements

One final objective was that, in order to allow critical play to arise(Flanagan, 2009), the design had to relate to human values, and at the same time avoid the authoritative museum voice(Samis, 2008). By providing an interaction in which the visitors can share their emotion, allows a visitor to participate regardless of their knowledge regarding the subject. In a framework of emotional social interaction there are no wrong answers. Participants were amused and shocked by the emotions other people have shared. It allowed them perceive a photograph differently that they would without the interaction.

However, due to the social elements of the design, a second problem arised. The design awards users for participating socially, however that requires data to be collected. That data collection is meaningful for permanent exhibitions or projects, however for temporal exhibitions - as our use case is - this is not a successful model, since for such a large collection - over 16000 photographs - a significant amount of time will be required to collect sufficient data. In addition, a large amount of visitors would get a uninteresting experience. Outsourcing the data collection could be one solution, however further research needs to be done in order to under how that could be done in a sound and complete way. Another interesting direction for further research would be to test how social elements could be utilized by designs that focus on temporary exhibitions.

To solve this problem, the algorithm displayed a random photograph as a

related photograph whenever no related photograph was found in the database. This created confusion among the participants, since that solution created situations where the photograph being suggested were contradictory to the emotion that was given as an input by the visitor. Not all participants realized that some of the photographs were random. Most of them, when asked, they said they would prefer to be informed whether or not the photograph that was displayed is random. Although this is a valid insight, it is questionable whether or not having that information would add anything to the meaningfulness of the experience. Furthermore, adding such a feature would further complicate the information that is communicated to the visitor, making the design more complex. That complexity could potentially make reflection more difficult since the visitor's focus will move towards the various elements of the interface. Nevertheless, more research needs to be conducted regarding the underlying problem, which is that when the meaningfulness of the interaction is relying on the submission of the visitors - the social element - how could that interaction be designed in order to ensure a meaningful experience for all the visitors, even the first ones?

5.3 Insights

In the previous section, I evaluated the design objectives that were initially set. The playtests revealed insights regarding those objectives, and how they affected the success or failure of the design. More importantly, the tests, revealed insights how playfulness can operate in the museum space, which proved to be a more important research question. Playfulness is often associated with non-serious, carnivalesque behaviour(Sicart, 2014). That association makes it difficult for playfulness to be accepted inside a cultural, and art museum space, since that is a reflective, serious space about cultural heritage. However, it is possible for museum interactions to contain ludic elements that support that reflective character. Those interactions can be designed through the "Critical Play" game design method(Flanagan, 2009), since critical thinking is prominent in cultural museums.

The results from the interaction, provide insights on how such an interaction could be designed. Minimalism is important in the overall design. The whole experience needs to be non-intrusive, in order to be in par with the exhibition, rather than stealing the focus away from the exhibition. Furthermore, minimalism allows the visitor to initiate the interaction immediately, instead of having to be instructed as to how the interaction works. The less time and focus the interaction requires from the visitor, the more time and focus the visitor will spend reflecting, and interacting with the exhibition through the lenses of the mixed reality interaction.

Another aspect that seems valuable is the social element of the design. Traditionally the visitors experience the museum space passively, observing the exhibits. Using social elements in museums interactions provides the visitors with agency over the museum space. It allows them to shape what other visitors experience, thus permanently changing how the exhibition is perceived through the interaction. That social element transforms the visitor from a passive observer to an active participant. After all, culture is about society and communication, rather than just observation.

However, further research is necessary to understand the implications of those elements, when designing for playfulness in the cultural sector.

Chapter 6

Conclusion

During this thesis, I attempted to answer the following question:

> *How can playful mixed reality interactions be utilized by museums, in order to expose the museum visitors to their digital collection?*

In order to answer that question, the "Critical Play" Game Design method, proposed by Flanagan (2009), was used, along with the trajectories conceptual framework described by Benford and Giannachi (2011), to design and develop an interaction for the *Keld-Helmer Petersen* exhibition, which is to be displayed in the space of the *National Museum of Photography* during the spring of 2019. The reason for that particular exhibition to be the focus of this thesis, was its large size - over 16000 photographs.

Playfulness

Playfulness has the ability to occupy, appropriate, and subvert serious spaces - spaces that are not built for play. Cultural museums are an excellent example of such space. Simultaneously, playfulness can be critical, and through that playfulness, participants can have reflective experiences in that space. Playfulness creates interactivity, and through appropriation, the participants gain agency over the space and the experience, which renders them active participants to the exhibition.

Mixed Reality

Mixed reality consists of both physical and virtual elements, and connects those elements together in real time. This model is the same as in the museum space, where there is a physical exhibition and a digital collection, and the museums desires to connect those two spaces. Furthermore, the trajectories conceptual framework, which was built by abstracting theory from mixed reality performances, properly models the museum space, since visitors traverse the hybrid museum space through trajectories - i.e. specific spatial and temporal points of interest.

Digital Collections

Due to the digitization of archives, museums have large digital collection of archives stored. As a result, museums have interest in exposing their visitor to those digital archives of cultural heritage. This is possible through digital interactions, since the museum space is limited, thus it is impossible to contain all the museum material.

Objectives

Through the literature review, the state-of-the-art, and conducting interviews with experts the following objectives were deemed as important for the overall design:

- Exposure to the digital collection
- Aesthetics
- Minimalistic Design
- Ludic Elements
- Social Elements

Through those objectives, the concept that is presented in this thesis was developed. After the design iterations that created the final version of the concept, that concept was tested through conducting expert interviews, playtests, and phenomenological interviews to the users that tested the concept. Through that process, I was able to evaluate my design choices and the objectives that where set in the beginning.

Findings

I discovered, that the ludic elements of the interaction, along with the social interaction that visitors had with each other - through the interaction - created a reflective experience towards the art that was presented. In addition, the overall minimalistic design, allowed the users to focus on the exhibition, and understand the rules of the interaction intuitively. Finally, by using those elements to give agency to the visitors, resulted in the visitors shaping the overall experience allowing them to actively participate to the exhibition, by submitting their emotions.

Those aspects could potentially be utilized in order to create playful, reflective, and social experiences in museum exhibitions. However, the results from this thesis only provide a general direction towards potentially beneficial future research, and cannot be generalized.

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