# Design research on engaging and educative museum experiences with the use of games within museum applications

**A case study of a treasure hunt game within the Nationalmuseum's application**

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## ABSTRACT

This paper discusses factors that affect engagement during a museum experience with a focus on applying gamification into a museum application. At the center of this paper, the educative and engaging purposes of a museum visit are situated and analyzed in the form of design research. Following the design thinking methodology, first a background study with relevant literature, theoretical framework, and related studies on existing museum experiences using games and mobile technology is presented. Moreover, in order to narrow down the perspective of the study a case study with an existing museum application is selected. As a result of this research, a prototype of a game within the Visitor Guide application of the Nationalmuseum of Sweden was created and tested in a showroom environment, in a museum exhibition. The aim of this study was to find out if a game within a museum application could engage the visitors while educating them. The findings create space for discussions about several topics, including different factors affecting engagement and how gamification can help to educate the museum visitors in a non-gamified environment.

### Author Keywords

User Experience; Museum Experience; Museum application; Gamification; Engaging Games; Educational Games.

## INTRODUCTION

Nowadays, to attract people in general, but also in museums means to create an experience as never before which evokes interest in people. The possibility of emerging technologies created an opportunity for a much more involved and immersed user experience enabled in museums. Portable technologies in our society such as mobile phones created a new way for entertainment, also to gather knowledge in a much more interactive manner. This applies to museum visits as well in order to engage the visitors and to create a memorable, unique experience. “Digital technologies can deliver large volumes and personalized information to target different learning styles and requirements, and this is what makes the technology so versatile and may lead to exciting new possibilities for museums in the future [58]”[37]. However, there is a problem with the lack of implementations of such technologies in museums in order to benefit the user experience. Furthermore, the issue is not only the lack of technology being used but missing interactions and uncertain coordination that comes as a result of the lack of planned user experience itself [28].

There is an increasing interest in understanding what affects a museum experience [14]. The usage of mobile technologies in museum environments involves much more than listening to audio guides and scanning in QR codes or typing in number codes in order to get information about the artworks exhibited. Wayfinding through GPS coordinates and other location-aware technologies have been used quite a lot lately since one of the most common problems within museums is the navigation within an exhibition, especially if the museum exhibition expands over a bigger scale [59]. However, another way to solve this problem in the case of The British Museum Guide was to offer different paths within the exhibitions regarding how much time the visitor would like to spend in the museum [16]. Moreover, casual games on mobile devices are not only a new way to attract museum visitors but also allow visitors to navigate throughout the exhibitions. The scavenger hunt, a game of searching for objects based on cryptic clues, is a popular type of mobile game being explored by many museums [59].

According to the results of the study by Palumbo et al. [44], there are 6 mandatory requirements in a museum application. Details about how to get to the museum are one of them, together with contacts of the museum as availability of background information. Moreover, a photo gallery of the main important artworks of the museum and a map of the museum showing where these artworks are located. Furthermore, there are some requirements related to the accessibility and usability of the app. It is supposed to have a multilingual option for foreign visitors and a user-friendly interface. According to the authors of the study “All these requirements are mandatory, so their presence is strongly recommended, otherwise they will cause high dissatisfaction levels. However, their presence does not increase the level of customer satisfaction because users take them for granted”[44].

Several studies have explored the role of entertainment in museum visits and the interaction between visitors and museum artifacts [43]. The use of serious games (SGs) to offer gaming experiences for museum visitors is quite a new concept in the sense that there is little known about the current trends behind the implementations and the actual

use of such a diversity of game genres related to museum's objectives and educational outcomes.

According to Kristianto et al. [26] gamification also improves learning in museums by giving the visitors a clear direction on what to learn during their visit. Moreover, mobile technologies can stimulate engagement and the visitor's personal imagination while creating meaningful effects on visitor's participation and learning effects related to the exhibition [50]. Despite the fact that there is an increasing number of studies reporting the positive learning effect of using games within museums, it is interesting to note that often there is no clear definition of how these learning effects were measured [43]. Therefore, this study is going to demonstrate evaluation methods while investigating the question; *How can an engaging museum experience be created with a game in a museum application in order to educate visitors in a more interactive and fun way?* The hypothesis of this study is that with help of a treasure hunt game within a museum application the museum experience could be experienced engaging while also educating the users.

## BACKGROUND

This section presents some engaging examples of current museum experiences in the form of games that inspired the process of designing the prototype in this study.

### Related work

*Virtual museums*

Virtual museum experiences are more and more common nowadays. To be able to check out the museum's website before the visit is a usual thing to do, which also gives the opportunity for a virtual round in many cases. Also, virtual museums often emphasize the post-museum experiences, as well as give more in-depth information and offer activities online.

*MET children*

Metropolitan Museum of Art (MET) in New York is one of the world's biggest art museums. They have created a virtual museum experience targeting kids called #metkids [64]. On this website, there are three possible experience paths to choose from. One is where the visitor could explore the museum map which is made in a cartoonish style (see *Figure 1*.) including artifacts of the museum with additional information. It can be described as a treasure hunt, displaying information in the following categories: watch, discover, imagine and create. Moreover, the fundamental facts such as who made the artifact, when, where, and what it is made of are fun facts that can be found on the webpage (see *Figure 1*). Also, another way of experiencing the museum is through a time machine as a searching option for different artifacts based on time periods, geography, and big ideas (see *Figure 2*). This page challenges the visitors with gamification features such as a button that is not supposed to be pushed, but when it happens it "destroys" the site presenting a random artifact in the end. Lastly, there is a third experience path through videos that inspire to create, have Q&A, and even include videos on different events and things made by children.

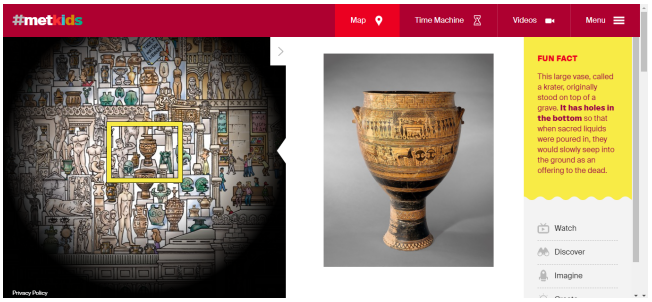



**Figure 1. The treasure hunt within #metkids**

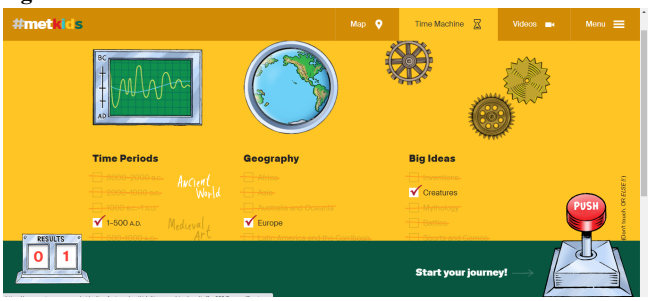



**Figure 2. The time machine in #metkids**

*Google Art & Culture*

The platform Google Art & Culture serves pre-visit and post-visit museum experiences with its digital database where not only its broad collection of artworks from different museums around the world is available, but other functions which engage the visitor. "Users can also create their own personal list of favorite cultural items in the same way as music playlists are created on Spotify or iTunes, share it on social media, write reviews, share photos, answer questions, add or edit places, thus acting as local guides in the digital world"[46].

Moreover, Google offers an additional gamification aspect to the museum experiences in the form of short games with an aim to generate knowledge in an entertaining way.

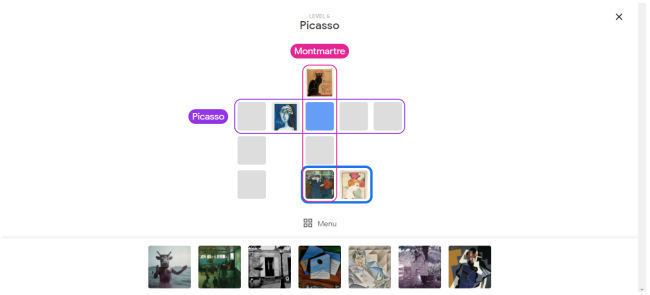



**Figure 3. Visual crosswords as part of the Google Art & Culture project**

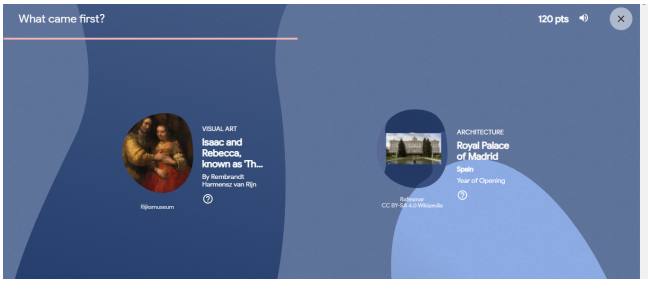



**Figure 4. What came first quiz by Google Art & Culture**

Google Art & Culture created a project called "Experiments" where users can participate in different game experients. Short games such as Puzzle party, Visual Crosswords (*Figure 3.*), What came first (*Figure 4.*), and Art coloring books are available to enjoy a wide range of art content together with friends or family or even individually. With Puzzle party users can "dive into the rich detail of over 500 artworks"[12], and choose between three different difficulty settings. Visual Crosswords use pictures instead of letters so users can figure out unexpected pairings where each artwork fits in the grid: "Is it Renaissance or Modern? Is it Van Gogh or Gaugin—or both?"[12] What came first compares seemingly unrelated facts which can help us put things in perspective and think differently [12]. There is a time limit and the faster the user decides upon what came first the higher score is being earned. Moreover, there is a possibility to read up on the compared items to deepen the knowledge. The dataset is split into 6 categories: visual arts, music, films, architecture, inventions, celebrities [12]. These games are simple and already familiar to the users making a social museum experience possible from distance.

*Brooklyn tagging application*

The "Gallery Tag!" of the Brooklyn Museum app is an interactive game with the aim of tagging museum objects in order to win points and awards. "It is based on the exploration and discovery of exhibits that, according to the players, fit a series of predetermined tags. The game includes roaming services (Roam!), encouraging visitors to find and tag objects from different floors of the museum and rewarding them with additional points, linking to the mobile version of the museum's website (Crossover!), and finally, convergence of the game's tags with the online collection (Covergence!), thus bridging the physical with the virtual collection. This game app has the potential to contribute to experiential learning and the personal construction of meaning through the active participation of visitors, while strengthening the entertainment potential of the museum visit" [9]. With the help of this application, the whole Brooklyn Museum could be explored on a pre-planned route. The learning experience however depends on the visitors' own effort put into the game. Even though the museum experience including the usage of the application offers an engaging way and another perspective to the users to take in the information about the exhibited artifacts.

*Scan NFC tags and QR codes*

"The "Wolfsoniana" android application allows visitors to scan NFC tags and quick response code (QR Code) markers to gain more information about the exhibit [4]. At the end of the tour, visitors are also offered to play a knowledge game where they are asked to visually match objects together based on the previously acquired information. Even if numerous experimental studies reported positive learning effects of such cultural heritage games, there is no proof how these learning effects were measured"[43]. As QR codes are a popular way of giving information in museum environments, the core of this game could be applicable to other museums as well. Similar to some of the Google Art & Culture projects, the "Wolfsoniana" application also connects the artifacts with information in form of a game. The fact that this game is based on cultural heritage highlights the possibilities of how to bring engagement into a rather serious field with the help of gamification.

*Tate Britain's Muybridgizer*

Another example of a museum application using gamification is Tate Britain's Muybridgizer. Based on the early photographer, Eadweard Mybridgizer users of the app could imitate the artist style by taking sepia-toned photographs and 'freeze frames' of moving subjects, which they could store and share through Flickr [9]. This is an application that could engage the visitors in an entertaining way, but it is missing the learning purpose. However, it also motivates the user of the app to share their experience with others which strengthens the shared experience and thus could increase the engagement level [59].

*Useeum*

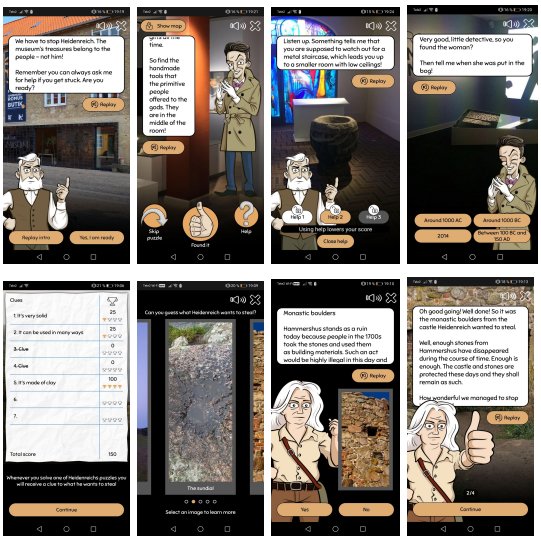


**Figure 5. Screenshots from The Museum Mystery treasure hunt games within the Useeum app**

Useeum is a Danish app including information related to different museums in Denmark. Through this one app, many participating museums can be experienced through storytelling, audio guides, and games as well. "The Museum Mystery is a fun and educational game, which motivates children and playful adults to explore museums, solve puzzles concerning the exhibition pieces, and learn about our cultural heritage"[60]. On Useeum's website, it is also stated that 95% of the time the game forces the player to lift their eyes from the screen and to look around in the museum[60]. However, the method and measurements for this result are not published. Nonetheless, "user tests of The Museum Mystery on children of the ages 6-12 show that the game:

1. Provides children with a fun experience at the museum
2. Creates curiosity, reflection, and learning
3. Engages the children for up to one hour
4. Is a social experience because it can be played by more than one person at a time

5. Motivates the children to visit other museums and continue the game" [60]

An interesting fact about "The Museum Mystery" is that it is a game that has been adapted to several museums and therefore it is an ongoing mystery that continues in other museums even if a mission has been accomplished in a particular one. The aim of The Museum Mystery is to stop Heidenreich (an avatar who follows along with the game and represents the bad guy, see *Figure 5*.) from playing his tricks. This ongoing storyline motivates the players to visit more museums in order to complete all the missions.

## LITERATURE STUDY

One of the first mobile applications for a museum visit was released more than a decade ago called Love Art (2009) for the National Gallery in London [15]. This app included a collection of artworks with audio files available for more information about the art pieces. However, already in 2001 there was a symposium at the San Francisco Exploratorium where several researchers and developers from industry, academia, and the museum world discussed the possibilities with electronic guidebooks within museum exhibitions [36]. Since then, museum applications serve different user needs and offer interactive museum experiences as well.

A museum experience starts before the museum visit and lasts after the visit, therefore it is important to look into how does pre-visit, during-visit, and post-visit museum experiences look like with a focus on museum applications. There is a need for museums to investigate what services should be provided to users throughout the process of Pre-Visit, During-Visit, and Post-Visit [30]. Studies show that 'During- Visit' experiences often relate to the physical museum, while the 'Pre-Visit' and 'Post-Visit' experiences mostly relate to the virtual museum [30, 34]. When it comes to pre-visit museum experiences usually the case is that practical information is offered in applications to prepare for the visit [9]. Some applications can only be used during the visit and audio guides are one of the most common features of a museum application used during a visit [9]. There are many museums that employ gamification strategies to entertain visitors during visits. More recently, mobile augmented and virtual reality has been used to improve engagement during museum visits. "However, current digital tools often fail to bring artifacts back to life on an emotionally evocative level" [45]. Not only the emotional aspects are an important part of an engaging experience, but the educative aspects of a museum visit are usually in the center of the interest for the museum visitors [55, 30]. Moreover, studies show that gamification also improves learning in museums by giving visitors a clear direction on what to learn during their visit [26]. Meanwhile, post-visit museum experiences within an application often mean revisiting the content of the exhibition through bookmarks for example through a personal collection of favorite artifacts.

### Museum experience with games

Gamification methods in museums provide more appealing and engaging ways of displaying cultural heritage according to López-Martínez et al. [32]. There are many ways of implementing gamification into the museum experience. According to Tsai and Sung [59], "the ARCHIE project showed that mobile games can enhance the social relationships between the museum visitors and provide a more immersive learning experience". Also, according to another study entertainment' accounts for the highest proportion (80%) of the audience's motivation to visit the museum [29]. Moreover, Paliokas and Sylaiou [43] refer to Gamified Learning Environments (GLE) as an attractive and effective medium to learn new information in a pleasurable way.

As the result of a study by Economou andMeintani [9] 64 museum applications were analyzed whereas most of the apps serve only the basic needs, with presenting guided tours and practical information about the museum visit, but rarely involve some sort of gamification such as content creation or manipulation of artworks and games (2 out of 64) based on the exhibition. However, it is stated in the study that the interactive character of the application, as well as its entertaining features, can contribute to audience development [9].

Treasure hunt games are a popular way of bringing interactivity and enjoyment into the museum experience. "However, with the objective being locating rather than interacting with the exhibits, some researchers have cautioned that straightforward scavenger hunt games can be counterproductive to learning because they don't encourage deeper thinking or thoughtful inquiry" [59]. Based on all the above-mentioned studies, ideally, museum games are supposed to be engaging and educative encouraging personal growth. The availability of games in museums opens up the possibility of having a personal experience which is also a central strategy for engagement [57, 13].

### Engagement and Gamification

There is no one particular definition of gamification, neither is there a clearly stated difference between Game-based Learning (GBL) and gamification [1]. However, some researchers agree upon the fact that gamification is the use of game elements, mechanics, features, design, and structure in a non-game environment or context [1]. This study will also present such an example as the gamification in this context will be included in a showroom non-game environment, in a museum. Also, in this study, Alsawaier`s view on gamification is applicable as it highlights the importance of learning and engagement [1]. According to Alsawaier [1] "Gamification is not when learning is changed into a computer game but rather when adding a design layer of game elements to enhance learning, increase engagement, and encourage positive behavior". Keeler claims [23] that GBL is when users play games in order to learn content. In contrast, gamification is using game elements in an environment outside of digital games according to Keeler [23]. According to Issacs [20] gamification is a tool to create an atmosphere associated with gameplay and learning while in GBL the aim is to learn the content. The above-stated references underline that

in the case of this study gamification rather than GBL is in the center of the project.

Engagement is an essential element of the player experience, and the concept is described in various ways in the literature. According to a study by Schoenau-Fog [55], player engagement can mean being immersed, involved, engrossed [31], investment in time, effort, and attention [2], being motivated through sensory, challenge-based, and imaginative immersion (SCI) [11], having fun [24], desire to continue playing [3], satisfy fundamental psychological needs for competence, autonomy, and relatedness [34, 51].

Positive emotions such as excitement can contribute to individual development. "For many learners, the fun part in a gamified environment is the product of solving problems and overcoming challenges as they engage critical thinking skills [...] are important qualities, according to Lieberman (2006), in the process of learning"[1]. Through game components such as "quest" and "achievement" which motivates users, gamification could improve learning in a museum [26]. Also, "rewards" and "challenges" target users' emotions which is also an important trigger for engagement [26].

It is important to distinguish between the different notions in order to answer the research question. In this study, player engagement is understood as a strong level of desire to continue playing in order to learn and achieve a goal. Moreover, engagement is related to emotions and motivations which contribute to individual development. Also, factors based on the following theoretical framework (see next section) are decisive when it comes to game experience and engagement: immersion, flow, competence, positive and negative affect, tension, and challenge [18].

## THEORETICAL FRAMEWORK

### User experience

User experience is a quite broad field with different perspectives on the notion itself. Therefore it is important to have a shared understanding of this definition as it is both important in the aspect of engagement and gamification. In the book "Technology as experience" McCarthy and Wright address [35 pg. 80] four experience threads as different ways to provide people's experience with technology. The four threads are as follows: the sensual, the emotional, the compositional, and the spatio-temporal. In regard to this study, the compositional thread is highly relevant as it puts the different parts of the experience in perspective with the whole experience just as in this case putting the museum experience in relation to the game experience. According to Mccarthy and Wright [35 pg. 87] "If one is looking at a painting, 'composition' refers to the relations between elements of the painting and their implied agency, and between viewer, painting, and setting. In an unfolding interaction involving self and other, in a novel, play, or technologically mediated communication, it refers to the narrative structure, action possibility, plausibility, consequences, and explanations of actions." It implies this study as well since the user experience of the game is dependent on the museum experience and the interactions in between the game and the visit and vice versa.

### Museum experience

According to Falk and Dierking [7] when a museum visit is characterized as an interactive experience it can result in increased knowledge of the visitors. Through personal, physical, and social contexts interacting with each other, the museum experience can be described as engaging. By this means, the interactive museum experience in this study is described as aligned with the notion according to Falk and Dierking [7] as the physical context can include the designed prototype together with the exhibition space with the artworks.

### Game Design framework

With gamification, the user experience itself is altered just as engagement. The well-known MDA game-design framework by Hunicke et al. [19] inspired four Game Design frameworks [17, 41, 52, 53]. Robson et al. [52] created a version of this MDA framework called the MDE framework where instead of aesthetics, emotions are more emphasized (see *Figure 6.*). The gamification framework includes game design principles in a non-gaming context (such as a museum environment) and it targets designers. This framework has been used during the defining and ideation phase [8] in order to identify and create game mechanics and foresee game dynamics and emotions during playing a game. LeBlanc [19] argued that the MDE framework helps both designers and players to accomplish a better gamified experience.

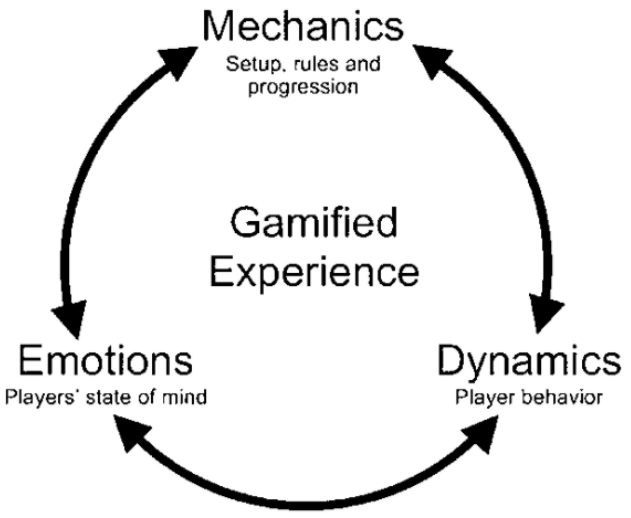



**Figure 6. Gamification framework [52]**

Mechanics are everything from defining a goal of a game to rules to different types of interactions to boundaries of game situations [52]. There are three types of mechanics, and "Setup mechanics" is one of them. Setup mechanics according to Robson et al. [52] considerations that shape the environment of the experience such as who plays with whom. Moreover, there is"Rule mechanics" that shape the concept or goal of the gamified experience to be pursued according to Elverdam and Aarseth [10]. Also, these mechanics can be time-based (e.g., time restriction) or

objective-based (e.g., unlocking levels). Furthermore, there is the third type of mechanics called "Progression mechanics" which describes different types of instruments that designers embed to affect the experience while it happens [10]. Important progression mechanics are leaderboards, badges, and levels for example, rewards with social significance. It is important to acknowledge that these gamification mechanics are set before the experience and they remain the same during the gamified experience.

In contrast to game mechanics, dynamics are the different types of player's behavior as an answer to the set mechanics by the designer [52]. For example, a team-based player structure (mechanics) can lead to cooperation (dynamics), while an individual player structure mechanics may result in competitive dynamics. However, when it comes to dynamics it is hard to predict by the designer as it is in control of the players [19].

Gamification emotions are reactions evoked during how players follow the mechanics and then generate dynamics [52]. According to Robson et al. [52] "in optimized gamified experiences, players' emotional responses and the dynamics that emerge during play shape the mechanics that govern play and vice versa". With that said, a gamified experience that is in control of both the users and the designers at some level is considered ideal. "As a result, understanding gamification mechanics, dynamics, and emotions and how these principles relate to one another is key for successfully gamifying an experience" [52].

**Process-oriented player engagement framework**

There have been many different ways of formulating what engagement means in games and why it is important. According to Schoenau-Fog [55] "It is not enough to motivate a player to begin playing – if the engagement is not sustained, the player will not keep playing." Some of the researches highlight the importance of immersion in games like it a form of engagement to being involved and to be engrossed [31, 2, 11, 22]. Moreover, motivation and enjoyment in the form of pleasure and fun have been associated with the concept of engagement as well [5, 63, 48, 24, 18, 25].

To create engagement in a game, the Process-oriented player engagement framework has been used throughout this study including objectives, activity, accomplishment, and affect (see *Figure 7.*).

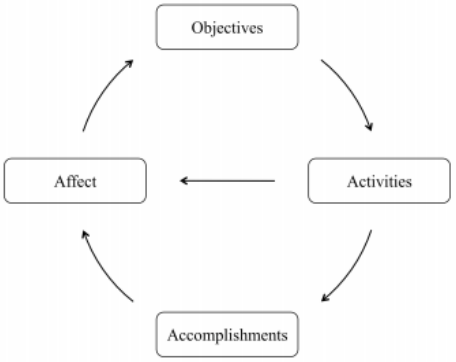



**Figure 7: Relations between Objectives, Accomplishments, Activities and Affect. (The OA3 framework) [21]**

*Objectives*

According to Schoenau-Fog [55] "the objectives component is concerned with what a player wants and the game-related triggers that motivate the player to continue playing." There are two distinct categories of objectives, extrinsic objectives, and intrinsic objectives. Extrinsic objectives are motivated by goals defined by the game, e.g., challenges. While, intrinsic objectives are intrinsically motivated, meaning self-defined goals made up by the player, e.g., goals not expected from the game itself.

*Activities*

"The component of activities is concerned with what players want to do in order to reach an objective"[55]. These activities can be divided into categories such as interfacing, socializing, solving, sensing, experiencing the story and characters, exploring, experimenting, creating, and destroying [55].

*Accomplishments*

The accomplishment component is about the results of the players' activities in order to reach the objectives. These accomplishments can be divided into categories by achievement, progression, and completion [55].

*Affect*

The affect component describes the emotions of the players which evokes during accomplishments and different activities of the game. These emotions could be either positive, negative, or absorption [55].

This method has been chosen for this study because it previously revealed: "that engagement can be explained as a process whereby players engage in a pursuit of objectives and consequently perform a range of activities in order to accomplish objectives and feel affect" [55].

**The educational purpose of the game**

As one of the main reasons for a museum visit is to have an engaging experience and to learn something new, the educational aspect of the designed game is aimed at this study as well [30]. To make the museum visitors learn and engage through the game the educational content in form of objectives, activities, and accomplishments were presented (see Engagement framework) and with the help of the right game mechanics implemented (see Gamification

framework). By giving directions to the players in order to learn about the exhibition the engagement with the help of gamification is sustained [26].

## METHODOLOGY

Throughout this study, the method of design thinking process was used [8]. It is a human-centered, innovative, and iterative design process with five phases. This method is also called "double diamond" since the name describes the perspectives of each phase with widening or narrowing ends (see *Figure 8.*).

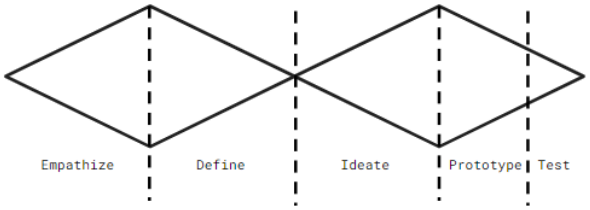



**Figure 8. The double diamond design thinking process based on Doorley et al. [8]**

### Empathize

The first phase is the empathizing phase where the user's need is in focus in order to understand their problem on a deeper level [8]. In an empathizing mode, the researcher observes, engages, and immerses according to Doorley et al. [8]. This phase is about quantitative (e.g.: questionnaires) and qualitative methods (e.g.: interviews with stakeholders) to collect as much data as possible to be able to empathize with the actual problem of the target group [6]. During this phase, problems might come to the surface that the studied target group is familiar with or may not be aware of [8]. Moreover, it is a phase where not only what the users say but what they feel and how they act are important to take into account.

In this study, the emphasizing phase included the related work as inspiration for the designed prototype, the literature review on existing trends and studies regarding the museum experience with a focus on museum applications, moreover, a theoretical framework that introduced the different notions and theories used in the study. Also, a case study of the Nationalmuseum's application is introduced in this phase as the questions within the pre-study were formulated in regard to all the parts mentioned above. The pre-study in form of an online questionnaire was sent out to the target group of museum visitors as the last step within this phase to emphasize with the users.

### Define

The next phase was the define phase, which according to Doorley et al. [53] is about to narrow down the problem and synthesize the empathy findings into compelling needs and insights, to scope a specific and meaningful challenge in an actionable problem statement, a Point Of View (POV). During this phase, the problem was framed focusing on creating guidelines to follow in the next phase with a central aim to clarify the focus of the study.

### Ideate

Following the define phase came the ideate mode, where the aim was to generate as many ideas as possible through brainstorming to explore a wide range of ideas with diversity [8]. Certain creative brainstorming methods were used under this stage such as sketching and mind mapping to uncover ideas related to game mechanics and engagement. Furthermore, the theoretical frameworks were there as guidelines throughout the process.

### Prototype

After the ideation phase, it was time for the prototyping phase, where the ideas got a form in the physical world. According to Doorley et al. [8], a prototype can be anything from a concept sketch to a high-fidelity prototype such as wireframes of an application. However, it does not necessarily need to be advanced unless it serves its main goal to reflect over a solution and create space for discussion with users [8]. Even though a successful prototype is interactive and helps drive deeper empathy [8]. Therefore, as part of this study, an interactive high fidelity prototype was designed in Figma.

### Test

The last phase of the design thinking method is to test out the created prototype, refine solutions and learn more about the user [8]. The prototype as it is advised was tested on the chosen target group for the project in order to gain relevant feedback and learn about the users [8]. In this case, the prototype was tested on the target group of young adults (between the ages of 24-29) as museum visitors. The people included in the user tests were both foreign and Swedish, both people who did know each other from before and people who did not in order to represent the general young adult museum visitors in an exhibition (see *Appendix 4.*). Furthermore, since the design thinking method is an iterative process, it was kept in mind that sometimes the results from the testing could show gaps regarding the POV and could lead to redefining the challenge and starting over again [8].

## CASE STUDY

### Nationalmuseum

Nationalmuseum is the National Gallery of Sweden located in Stockholm. As it is highlighted on their website, the knowledge about the artworks is also in focus in the museum: "Nationalmuseum is Sweden's museum of art and design. Nationalmuseum is also a government authority with a mandate to preserve cultural heritage and promote art, interest in art and knowledge of art. The collections comprise of painting, sculpture, drawings and prints from 1500-1900 and applied arts, design and portraits from early Middle Ages up until present day" [40]. By this means the Nationalmuseum is targeting people on a broad scale with different needs and interests. The Nationalmuseum extends the museum experience [7] on virtual spaces as well with their museum application. During the year 2018, the museum invested in developing an application which the

visitors could use before the visit, under the visit, and after the visit [39]. The application Nationalmuseum Visitor Guide presents thousands of artworks from different exhibitions, background information about them, and various audio tracks.

According to the museum's regulation letter [39], the National Museum is tasked with reporting activities that correspond to the young person's needs and efforts to increase the young audience. Some activities targeted at children are present in the museum application. There are audio guides specially designed for children in order to create an interest in regard to a museum exhibition with the applicable narrative. However, audio guides could be seen as passive interactions without triggering the users for deeper thinking [59]. Additionaly, young people not only include children, but young adults as well whose needs still need to be considered. Moreover, there are workshops and video materials uploaded on the museum's webpage targeted to children although these are post or pre-visit museum activities. In other words, there is still a lack of interactivity and engagement during the visits of the Nationalmuseum in order to offer knowledge about the exhibited art in an enjoyable way for a young target group.

*Visitor Guide*

The application of the Nationalmuseum serves the museum visitors with audio guides, stories, and in-depth information about the artworks exhibited. The artworks can be found through number codes within the app or even through the collections of the exhibitions, but it is not possible to search them by title or artist name. However, there is an opportunity for saving the artworks to a favorite list in order to find them next time more easily and to be able to read up on them later. Furthermore, the application offers an overview of the museum building in the form of floor maps. These floor maps are found in many cases within the audio guides indicating where the presented artworks are. Even though the application is designed for a museum experience before, during, and after the visit the focus of the application is to guide the visitors throughout the actual visit.

*Feedback from users of the Visitor Guide*

5,4% of the museum visitors use the application, approximately 400-650 visitors per day [38]. 200 users use the application more than an hour on average, and the average visitor does two sessions per occasion which are 10 minutes long [38]. Whereas the audio guides don't count as active usage. However, there is little use of the application visible in the museum. From 2018 Oct. 1st - 2019 March 21st, 60,9% of the users were recurring visitors which talks about the functionality of the application [38]. The users are mostly between the age of 15-34 (33,5%), from which people between the age of 18-24 are the core users (27,5%) [38]. The proportion of male (54,15%) and female(45,85%) users is close [38]. According to the feedback from the application users, there is a high demand (75 out of 88) in regard to being able to search for artifacts, artists, etc [38]. Moreover, some interesting insights were pointed out by the users such as it is hard to find the artwork described in the audio guides, the full-screen mode would be favored for pictures of art, and that the possibility of having a map that indicates the selected artifact would make the visits easier [38]. The feedback empathizes the need for making the visits more user-friendly in regard to finding the artifacts easier and bringing forward the visual experience more.

The previously mentioned findings point out, that it is of great importance for the Nationalmuseum to find new ways to increase the interest among the young audience. Also, studies show that in order to attract more young people to participate in museums, the complementary relationship between the physical museum and virtual museum is important [34]. Moreover, education and enjoyment are the two main purposes of a museum visit which can be approached by gamification especially when it comes to displaying cultural heritage [21, 23]. Based on the above-stated insights, implementing gamification into the Nationalmuseum's app in order to attract more of the younger audience to educate them in an enjoyable way seems to be a reasonable direction to take on.

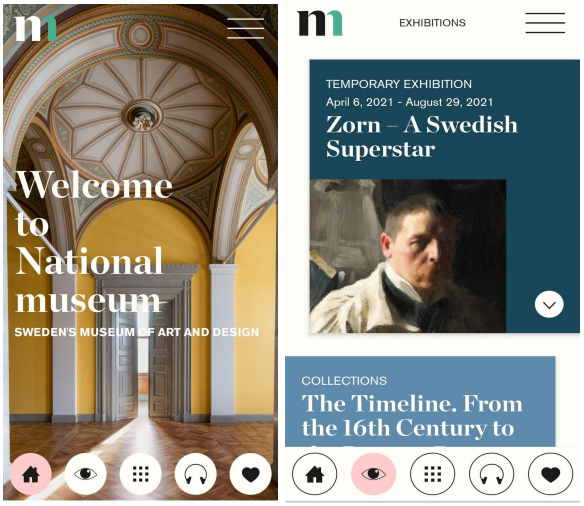



**Figure 9. Screenshots from the Visitor Guide application**

## EMPATHIZE PHASE

As it was described in the methodology section before, the empathizing phase focused on the findings presented in the background in the form of related work, literature review, theoretical frameworks, and the case study of the Nationalmuseum. Based on these sections it can be concluded that in order to create an engaging museum experience a game within a museum application at a certain point of the museum visit could be of interest for the museum visitors. To map out the problem and the possible ways of improving the museum experience with the help of a museum application a pre-study questionnaire was created.

### Pre-study Questionnaire

As a pre-study, an online survey was created to collect data from the users in order to map out the actual problem and to collect insights in regard to short games and the usage of mobile applications in a museum experience. According to Marsh [33] surveys are accurate before a redesign to learn

about the users' level of satisfaction with the current experience or in order to explore the reasons people visit or use a product or service. In the case of the study, the survey's aim was to explore the museum visitor's interest in possible future improvements. Moreover, Marsh [33] pointed out that surveys are good for ranking content or rating specific features. Therefore, the questionnaire about the museum experience study included Likert scales to rate different games used together with others or individually before, during, or after the museum visits. Also, ranking different game elements were part of the survey.

In order to get a better understanding of the user group, the museum visitors, an online survey was designed. It included questions divided into four different sections (see *Appendix 1*.). The aim of the questionnaire was to map out the interest in short games in a museum application in order to offer a more engaging learning experience for museum visitors.

The first section was about general background information and regarding museum visits, for getting a picture of what type of a museum visitor is the user. The second section was about the usage of museum applications in general, to map out the already existing and possible mobile habits when it comes to a museum experience and the needs in regard to pre-visit, during-visit, and post-visit experiences in museums. The third section was about expressing opinions in regard to short games, in order to measure the interest and to find a pattern in what games are more attractive than others for the museum visitor. While the last section involved questions in connection to the Nationalmuseum in Stockholm, to target the users of the Nationalmuseum's application as it is the case study of the paper and which will be further investigated in the form of a prototype.

The survey was distributed to 13 Facebook groups in connection to museum visits, virtual tours, engaging museum tours, etc. Moreover, it was sent out to my own network. By this means, the survey targeted a wide range of people. The survey was available for two weeks and resulted in 92 answers.

*Results (age, usual visit, and usage of a museum app)*

Out of 92 respondents, 36 were between the age of 26-35 and 32 between the age of 18-25. As the primary users of the Nationalmuseum application are between the ages of 15-34 the answers are considered regarding the case study.

Moreover, 80 respondents visit museums with company usually. Out of these participants, 76 have never used the Nationalmuseums application before even though 35 of them have been in the Nationalmuseum of Sweden. Also, 60 of the museum visitors who go with company have not even used a museum application in general. 65 out of 92 respondents in the survey have not used a museum application before. This means that more people with company tend to use museum applications than people who go alone. The majority of the participants (42 out of 92) in the questionnaire visit museums a few times a year.

63 out of the total 92 respondents expect to learn something new from a museum visit, just as the same amount expect to have an engaging experience. 41 of the participants expect to learn and engage as well. Meanwhile, only 32 participants expect to relax during a museum exhibition. This means that learning and engaging are more expected over relaxing from a museum visit. Moreover, some further expectations were highlighted such as to get inspired, get updated on exhibitions, and experience the culture.

27 of the participants have used a museum application before, of which most of them have used it for audio guides (23), for education purposes (21), and for navigation throughout the museum exhibitions (18). Moreover, 18 of the participants who have used a museum application before used it for audio guides and education purposes, which is more than those who have used it for audio guides and information (13) or audio guides and navigation (14). 5 people used it for entertainment purposes. An interesting fact is that out of these people all of them also have selected education purposes. Also, none of the participants who have used a museum application before used it for socializing purposes such as like and share content.

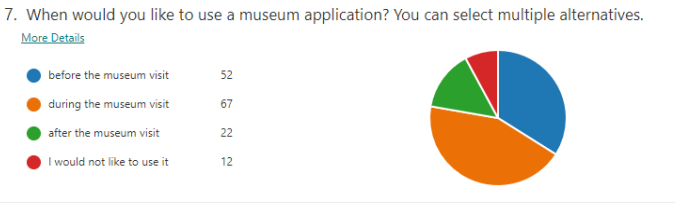



**Figure 10. Diagram showing when the participants would like to use a museum application**

67 out of 92 participants would like to use a museum application during the visit, while 52 would like to use it before the visit, 22 after the visit, and 12 would not like to use it. 39 people out of 92 would like to use a museum app before and during the museum visit, while 17 study participants would like to use it during and after and 14 people would like to use it before and after. 12 out of 92 participants would like to use a museum application before, during, and after the visit. Also, something to point out is that out of those 12 people who would not like to use a museum application 2 could still think about using it after the museum visit.

*Results (pre-visit with museum app)*

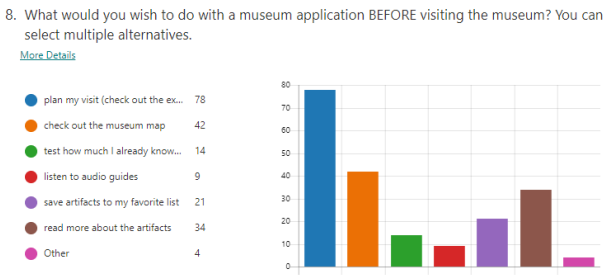



**Figure 11. Diagram showing what would the participants wish to do with a museum application before the museum visit**

A popular choice of pre-visit activity with a museum application is to plan the visit. 78 people selected “plan my visit” to do before the museum visit within an application. Moreover, the next two most popular choices in a museum application before the visit are to check out the museum map (42) and to read more about the artifacts (34) before a museum visit.

*Results (during-visit with museum app)*

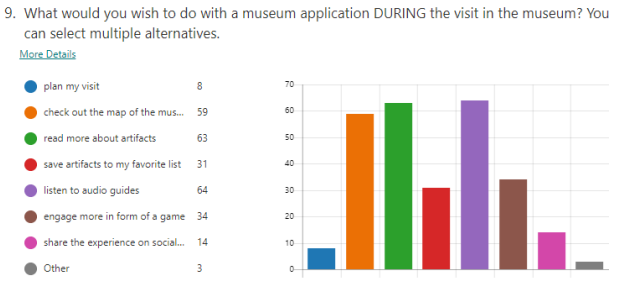



**Figure 12. Diagram showing what the participants would wish to do with a museum application during the museum visit**

Out of 92 of the participants, 64 would wish to listen to audio guides during a museum visit, while 63 answered that they would wish to read more about the artifacts and 59 people would like to check out the map of the museum before the museum visit. Moreover, 34 of the participants would like to engage more in the form of a game, 31 would prefer to save artifacts to a favorite list and only 14 people would wish to share the experience on social media. The results show that a during-visit experience in a mobile application is more wished to be about passive activities such as listening, reading, and checking out the map. Meanwhile, the more interactive interactions such as engaging more in the form of a game and saving favorites to your favorite list just as sharing the experience on social media and finally planning a visit were not as favored by the majority. Furthermore, there have been other wishes empathized such as get more content, bigger experience through the application during the visit or engage more in the form of a game as well.

*Results (post-visit with museum app)*

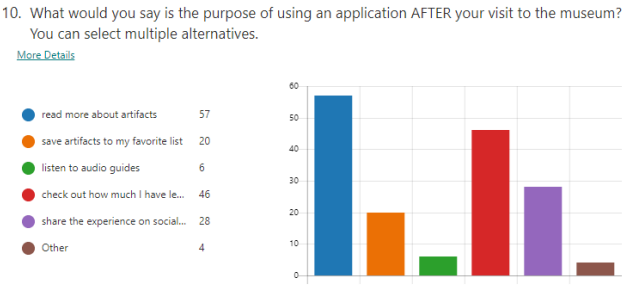



**Figure 13. Diagram showing what the participants would wish to do with a museum application after the museum visit**

When it comes to post-visit activities in a museum application, 57 people expressed their wishes in regard to reading more about artifacts, while 46 wished to check out how much they have learned from the exhibits in the form of a game. To share the experience after the visit (28) showed to be more interesting than as a during-visit activity(14).

*Results (short games when and with whom)*

When the participants of the study needed to rate alternatives about when they would prefer to play short games and with whom, the results showed the following conclusions. If it is about playing individually, the majority of the participants showed a bigger interest towards after the visit occasions in order to check out how much they have learned from the exhibits (20,7%). However, more people somewhat agreed with the statement that it would be fun to play short games during the museum visit individually (30,4%) than after the visit individually (28,3%). At the same time, it is expressed on a high level that the thought of playing short games individually before the visit is not so popular among the participants (6,5%). In contrast to this individually playing experience, the thought of playing together has not changed as much of the average ratings in regard to the different occasions. With that said, there is only a slight change in percent when it comes to how many people agree or disagree on when to play short games together. In general, playing together with others scored higher than individually, no matter the time.

The mode is the value that appears most often in a dataset. The mode was 4, meaning most people somewhat agreed on the statements that they would like to play short games during and after a museum visit whether individually or groupwise, while the mode was 1 meaning most of the participants completely disagreed on playing short games before the museum visit either individually or groupwise. This result highlights that a during-visit or post-visit game experience is more favorable than a pre-visit one.

*Results (what type of short games)*

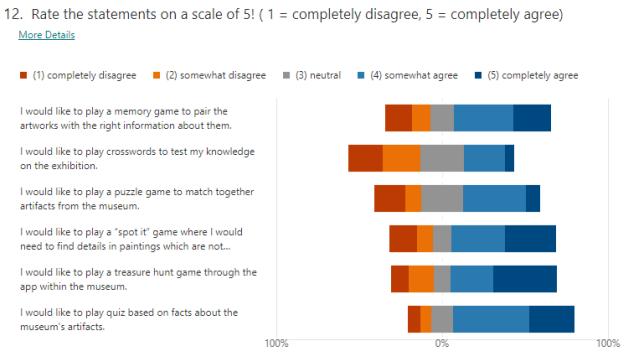



**Figure 14. Diagram showing the results of the most and least favored short games on a scale of 1-5**

Another rating task that the participants filled out in the survey resulted in more contrasting answers in regard to what types of games they would be interested in. The treasure hunt game through a museum application scored the highest among the other game types (38%). Moreover, the ”spot it” game was the next most preferred game (30,4%). However, the quiz idea has reached the highest score in the ”somewhat agree” category(45,7%). On the other hand, playing crosswords was the least liked idea (5.4%). To play a memory game (35,9% somewhat

agreed,22,8% agreed completely) or puzzle (38% somewhat agreed, 8,7% completely agreed) were still quite liked, but they did not get into the top 3 liked games.

The mode value was 5 on the statement that the participants would like to play a treasure hunt game, meaning most often this value appeared in the dataset which corresponds to completely agree. Only the treasure hunt had the mode value 5 which highlights that out of the six games the treasure hunt game was the most favorable.

*Results (interact with artifacts)*

67 out of 92 of the respondents would like to interact with artifacts from selected exhibitions, 45 with artifacts from a favorite list, and 31 with artifacts from the archive of the museum. Moreover, 8 of the participants would not like to interact with artifacts at all.

*Results (game elements)*

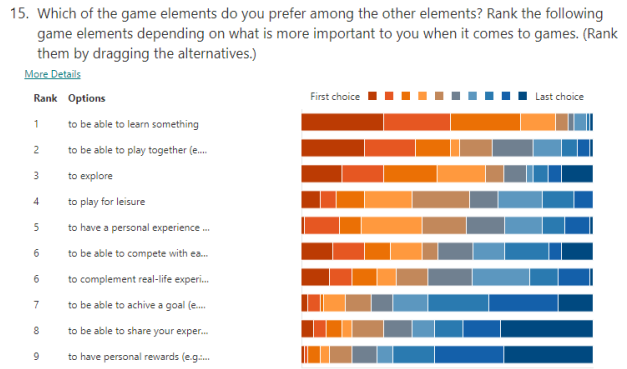



**Figure 15. Diagram showing the preferred ranking of the game elements by the participants**

When the survey participants needed to rank game elements depending on what is more important to them the most important on an average level turned out to be to learn something, while to have personal rewards got least prioritized. To be able to play together and explore got the second and the third most favored place in the average order. The Figure above shows the whole average ranking.

*Results (Nationalmuseum)*

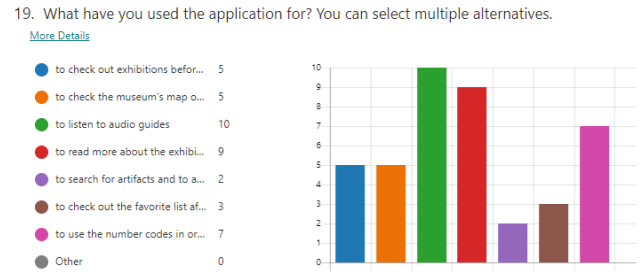



**Figure 16. Diagram showing for what have the participants used the Nationalmuseum's application**

Half of the participants (46) have been to the Nationalmuseum of Sweden before, but only 11 people have used their application. Out of these 11 people who have used the Nationalmuseum's Visitor Guide 10 of the participants have used it to listen to audio guides, 9 to read about the exhibitions, 7 used it to get more in-depth information about the artifacts based on the number codes. 5 people used the application to check out the exhibitions beforehand and to check out the map. 3 of the participants used the museum application to check out the favorite list after the visit and 2 people also searched for artifacts to add to the favorite list. 8 people out of 11 used the museum application during the visit, 7 after the visit, and 6 before the visit.

*Highlights from the results*

Some of the findings are more important than others. One takeaway from the results of the questionnaire is that most of the participants 80 out of 92 (87%) go with a company to museum visits. Furthermore, most of the participants (76%) expect to learn something new and have an engaging experience from a museum visit (63 out of 92 in both categories). Most of the participants, 67 out of 92 (44%) would like to use a museum application during the visit. When it comes to engaging in form of games 34 out of 92 respondents (37%) answered that they would be interested in it during a visit. Even if there was a greater enthusiasm towards engaging in form of games during a visit than before the visit, the most appealing time for playing games turned out to be after the visit with 46 votes (50%). However, the question was measuring the interest in playing a game which would have the aim of showing how much have the visitors learned from the visit. When the question was formulated in another way, focusing on when and with whom the participants would like to play, the results showed that playing games groupwise no matter the time would be more fun. Except, playing short games after the museum visit individually would be completely fun for the same number of people (19 out of 92) as playing groupwise (20,7%). When it was a question about what type of game would be of interest, the treasure hunt game scored the highest by 35 out of 92 respondents (38%), the ”spot it” game was the next most preferred game with 28 votes (30,4%) and the quiz idea as the third-highest preferred game with 25 votes (27,2%), but with the highest score on the ”somewhat agree” category with 42 votes (45,7%). Most of the participants, 40 out of 92 (44%) answered that they would prefer to interact with artifacts from selected exhibitions. Moreover, the top three preferred game components were learning, playing together, and exploring.

## DEFINE PHASE

To summarise the most relevant insights from the questionnaire in regard to what game in what circumstances might be of interest for the museum visitors in a museum application, some of the keywords representing the key findings were put out on post-its (see *Figure 17.*). The findings were defined in the following statement: The majority of the participants of the survey would like to play treasure hunt with the artifacts from a selected exhibition together or individually during the visit in order to learn something new and engage. This statement can function as a POV (Point of View) framing the design challenge.




**Figure 17. Important insights from the questionnaire**

In order to ideate on the question; "How might we create an engaging treasure hunt game from which the museum visitors can learn during a museum exhibition?" gamification and engagement frameworks were studied during the ideation phase.

## IDEATION PHASE

### Gamification

The ideation phase had begun with creating a mindmap over the different game mechanics and possible game components in relation to a treasure hunt game. As it is highlighted in the MDE gamification framework, game mechanics, dynamics and emotions are important to think about for a better game experience which is why they were an important part of the ideation [52]. According to Werbach and Hunter [61] game mechanics drive the actions forward and generate player engagement. The authors identified 10 important game mechanics which became the focus of the brainstorming. However, the green highlights indicate the chosen mechanics for the game. The game mechanics are the following:

1. Challenges (puzzles or other tasks that require effort to solve)
2. Chance (elements of randomness)
3. Competition ( one player or group wins, and the other loses)
4. Cooperation (players work together to achieve a shared goal)
5. Feedback (information about how the player is doing)
6. Resource acquisition (obtaining useful or collectible items)
7. Rewards (benefits for some action or achievement)
8. Transactions (trading between players, directly or through intermediaries)
9. Turns (sequential participation by alternating players)
10. Win states (objectives that make one player or group the winner - draw and loss states are related concepts)

According to Werbach and Hunter [61], components are more specific forms mechanics or dynamics can take. The authors have identified 15 important game components [61], whereas some of them have been built upon in the brainstorming mind map (see the green highlights).

1. Achievements (defined objectives)
2. Avatars (visual representations of player`s character)
3. Badges (visual representations of achievements)
4. Boss fights (especially hard challenges at the culmination of a level)
5. Collections (sets of items or badges to accumulate)
6. Combat (a defined battle, typically short-lived)
7. Content unlocking (aspects available only when players reach objectives)
8. Gifting (opportunities to share resources with others)
9. Leaderboards (visual displays of player progression and achievement)
10. Levels (defined steps in player progression)
11. Points (numerical representations of game progression)
12. Quests (predefined challenges with objectives and rewards)
13. Social graphs (representation of players` social network within the game)
14. Teams (defined groups of players working together for a common goal)
15. Virtual goods (game assets with perceived or real-money value)

Challenges in the form of giving close-up photos, mirrored lettering, picture codes, riddles, quiz questions, associations, encryptions, puzzles, crosswords, hints, and clues were considered during the brainstorming. Moreover, some ideas of what these hints and clues would be were named in the mind map such as the style of the painting, the background story of a painting, and the title of the artworks. As shown in *Figure 18-19*. how to include chance, competition, and cooperation mechanics were also highlighted in the mind map with some game components and further ideas.

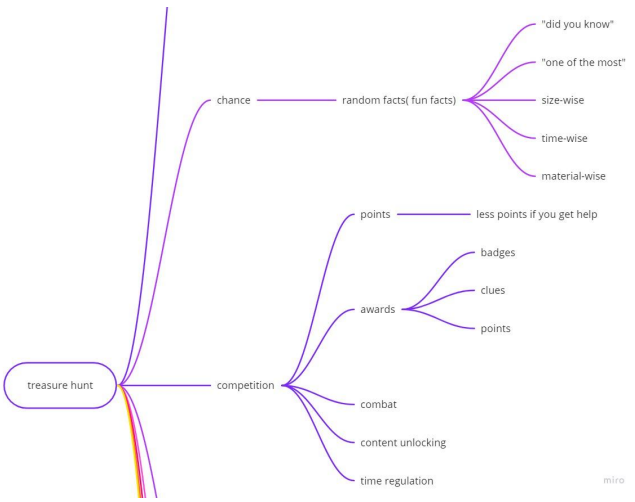



**Figure 18. Close-up from the mind map indicating the chance and the competition mechanics**

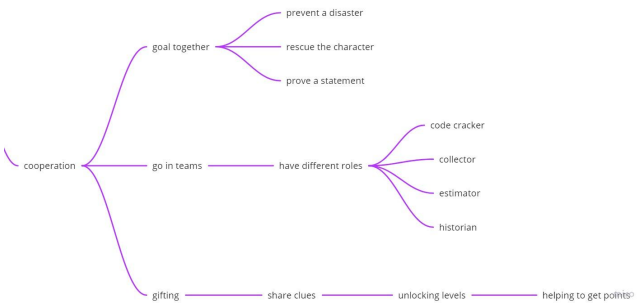



**Figure 19. Close-up from the mind map indicating the possible cooperation mechanics with game components**

Also, the mind map included ideas on how to give feedback in a game, such as through leaderboard, point system, and helper cards. Finally, the possibility of trading clues or hints in order to trade badges was also kept in mind. However, the green highlighted content from Werbach and Hunter's list [61] in regard to both mechanics and components were primarily used to build up the prototype.

### Engagement

Moreover, the Process-oriented player engagement framework has been used to make sure to create engagement in the game together with the chosen game mechanics and components [55]. By defining objectives, activity, accomplishment, and affect the player-engagement was hoped to be sustained through playing the designed treasure hunt.

Objectives:

- extrinsic
  - challenges in form of riddles and clues
- intrinsic
  - through elements of randomness (multiple choices, broad hints) giving the possibility to explore

Activities:

- solving
  - figuring out riddles and clues
- sensing
  - visually through artworks
- experiencing
  - museum exhibition with the treasure hunt
- socialising
  - solving the riddles together
  - competing with each other

Accomplishments:

- achievements
  - finding out what the riddles are about
  - collecting clues
  - collecting points
  - finding the treasure
- progression
  - gathering points by answering right to the riddles
  - gathering clues in order to find the treasure
- completion
  - gathering as many clues as possible
  - gathering as many points as possible
  - winning a badge after finding the treasure
  - free ticket as an award after 3 badges from different treasure hunts

Affect:

- positive
  - higher score in case of right answers
  - learning through riddles, clues, and the treasure
- negative
  - lower score in case of failing the riddles, using help, or skipping the riddles

### PROTOTYPING PHASE

Following the ideation phase, the prototyping phase has begun. As the key findings pointed out ( see *Figure 17*), it was clear that the prototype is going to be a treasure hunt game with the possibility to interact with artifacts from a selected exhibition. Therefore, the first thing to do was to select an exhibition from the Nationalmuseum. The fact that only one exhibition opened in the Nationalmuseum for the public in April due to the COVID pandemic has affected my decision. Regardless, it is a temporary exhibition over a Swedish artist called Anders Zorn it gave the possibility for testing the prototype in a museum environment which is determinant and therefore was no longer questionable in this pandemic situation.

After the exhibition was chosen, research had begun for finding some fun facts about Zorn and about his career. As the Nationalmuseum's Visitor Guide app is continuously updating information about the exhibitions, in the form of audio guides and text-based information some background story about Zorn's artworks was found in the app. Moreover, in order to give a variety of information and for a more engaging experience other sources have been discovered. Research studies on Zorn's work together with numerous web sources were read to find some interesting facts [49, 56]. After some facts were gathered, I started to outline the flow of the game based on the previous stages of the process, especially taking into account relevant works on treasure hunt games. One of the main inspirations for the flow of the designed treasure hunt game was Useeum's treasure hunt [60] where riddles lead to clues that result in pointing out the treasure.

When the sketches were done over the user flow, I started to build a high fidelity prototype in the digital tool Figma. Based on the existing graphical appearance of the Nationalmuseum Visitor Guide the treasure hunt game was about to be born (see *Figure 20-22*). The prototype for the game "Zorn's treasure" has the following potentially novel and interesting qualities:

- 5 riddles, mysteries to solve in order to find the treasure of Zorn.
- A hint per riddle to help without impacting the overall score.
- Possibility of additional help, which decreases the overall score.
- 1 clue for the treasure per riddle (if the user answers right).

- Feedback after each answer with educative content (either after wrong or good answer).
- Finally, guessing the actual treasure among 3 possibilities based on descriptive content.
- Also, get an award (Zorn's badge) if the user guesses the treasure right.
- After 3 badges collected from 3 different treasure hunts within some of the Nationalmuseum's exhibitions, it results in a free ticket.

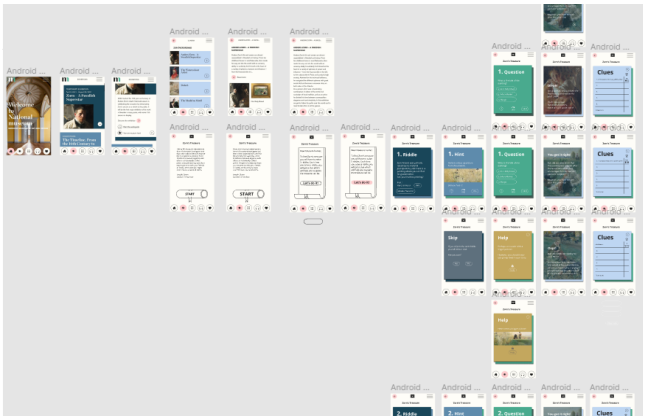


**Figure 20. Overview of the wireframes from the start to the end of the first riddle in a high fidelity prototype made in Figma**

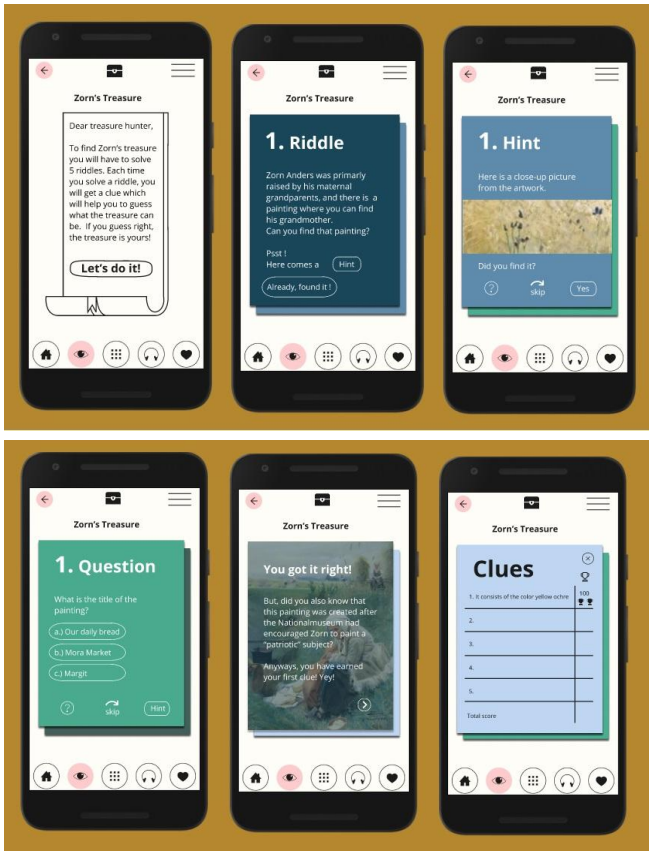



**Figure 21. User flow over the first riddle without using help resulting in a clue, because of a right answer**

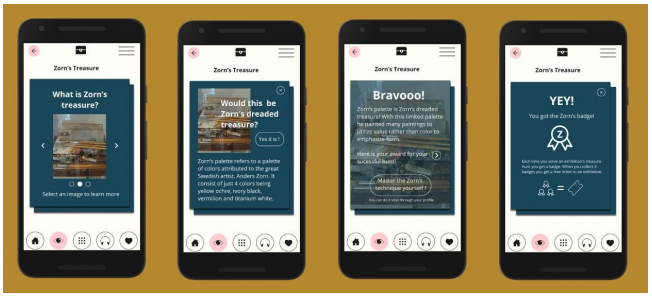



**Figure 22. Flow over finding "Zorn's treasure" after the fifth riddle**

## TESTING

### User study

"Usability testing (also known as user testing) is a commonly used method, where a researcher observes users who work through tasks on a product or service to identify where problems are encountered" [33].

In this study, the user tests were carried out unmoderated without the intervention of a moderator but with observations. As it is articulated by Marsh [33] "through observation, users of using a specific service or tool can be effectively understood through unmoderated usability testing".

The user tests were taking place during a museum visit in a chosen exhibition (a temporary one about Anders Zorn). According to studies unmoderated tests are often more realistic and unbiased than moderated usability testing [33]. The tests were conducted on 8 people in total divided into two groups on different days, one morning a group including two pairs of people who know each other from before and another morning a group with people who do not know each other from before were tested (see *Appendix 4.*). The testings were held before visiting hours and started with two people at the exhibition starting the treasure hunt at the same time. After a 10 minute delay joined the other pair in the exhibition to start with the first riddle. The delay was necessary in order to avoid the crowdedness in front of the same paintings and the possibility of overhearing answers. The tasks were given within the application prototype. Each pair had one phone at least, but in the case of one pair who didn't know each other both had their own phones with the prototype. At the beginning of each testing, the project was shortly introduced together with the process of testing. During the testing, the participants were encouraged to think aloud or at least talk naturally with each other as they would do during an ordinary visit meanwhile silent observation was undergoing. The tests took 45 minutes each time. After the usability test, the participants were asked to fill out a post-usability questionnaire online and to book time for a follow-up interview.

*Results from observation*

Throughout the observations during usability testing, the participants' interactions within the treasure hunt along with the exhibition and within the groups were examined. The majority of the groups went directly towards the right painting in the beginning. The pair who did not know each other from before and had their own phones individually to solve the treasure hunt got separated after the first riddle as

they wished to move in different directions. However, they were communicating with each other during the game mostly when they found the paintings. The other groups were discussing all the questions together while moving in the same direction. Even though in the case of those groups in which there was only one phone at usage there have always been two different roles, one who had more control over the phone and the game and another one who was more of an explorer and looked for paintings and information on a free level. However, these roles were not set and pre-defined but were something that came naturally to all group members.

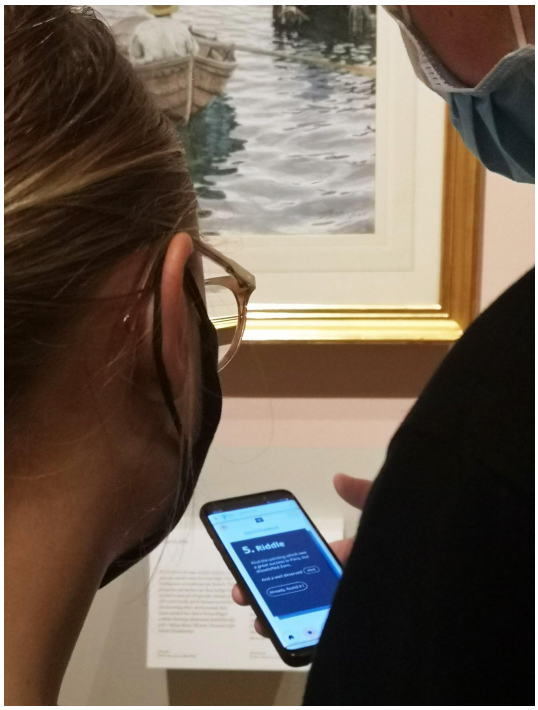



**Figure 23. Solving a riddle during the user test**

It happened quite often, that before the participants read the hint, they got excited to wander around and try to figure out the riddle on their own. More than once other paintings than the given alternatives in the questions were discovered which points out the difficulty level of the riddles and that the game motivated the users to discover and pay attention to the paintings at the exhibition. The expressions *"Oh, I know where it is!"*;*" It has to be here!"*;*" This, this was a success in Paris!"* highlight the participants' involvement and engagement during the game and that they were able to recall some information that they have just gathered.

Sometimes there were confusions, in regard to the connection between the hints and the questions. As it was expressed by one of the participants *"What it has to do with the painting?"*. However, hints were experienced fun and appropriate for most of the time. *"Haha! That's so true!"* or *"Oh so smart!"* were some of the reactions which indicated that.

Even though the different pairs weren't collaborating with each other the game brought them together at some points during the testing. It happened sometimes that the groups arrived at the same paintings at the same time. Whenever it happened the discussions got more private and quieter between the pairs, showing a feeling of competition with the other group.



**Figure 24. Two of the groups during the testing trying to find the right answer.**

There were some paintings that were harder to find since the groups needed to move within the same rooms as everyone else for security reasons. The possibility of exploring the exhibition freely was limited to specific rooms. Therefore, some of the participants needed to guess at some point, especially during the first testing. The second testing was a bit more coordinated as after the first round it became clear that in such a big exhibition with a time limit a little help is more than useful. Also, one of the groups could not fully finish the game due to lack of time during the first testing, however, they thought they have finished after reaching the last clue.

The participants got very excited when they succeeded to find the treasure, and those who did not succeed got a bit frustrated that they were not able to try it again, however, they have emphasized that they have enjoyed the game no matter the final result.



**Figure 25. Showing the different group dynamics**

## EVALUATION

### Post-study questionnaire

According to Sauro and Lewis [54], standardized measures offer many advantages to practitioners. There are different types of post questionnaires to evaluate design solutions. For this study, the Game Experience Questionnaire (GEQ) was used for usability evaluations of the designed treasure hunt game which is designed to quantify player experience through the following seven dimensions; Immersion, Flow, Competence, Positive and Negative Affect, Tension, and Challenge [18]. Moreover, for a robust measure, five items per component are needed and therefore presented according to IJsselsteijn et al. [47, 18]. The GEQ is a popular game questionnaire being used for usability evaluations of games. However, for this study questions about engagement and the educative purpose are in focus as well, therefore additional items were added to the GEQ. The aim of this questionnaire was to record the museum game experience anonymously right after the user tests and to be able to indicate the engagement level, how motivated did the participants feel to learn and to measure other aspects of the game. The post-test questionnaire was digital and included 40 short and simple items to be evaluated on a scale of 5 (where the numbers indicated the followings; (0) not at all, (1) slightly, (2) moderately, (3) fairly, (4) extremely) (see *Appendix 3.*). With help of these post-usability tests together with the follow-up interviews the evaluation of the prototype proceeded through thematic analysis [8], and by looking at the most frequently occurring answers.

#### *Results of the post-usability questionnaire*

Following the scoring guidelines for evaluation [47, 18], the competence during the treasure hunt game showed to be fairly rated on average. By looking at the mode in each item per category, the most often occurring scores and opinions were highlighted in order to gain a broader picture. 4 people out of 8 felt fairly skillful, 3 people felt moderately and 3 felt fairly competent, 4 of the participants felt moderately good at it, 5 of them felt fairly successful and 3 were slightly meanwhile 3 were moderately fast at reaching the game's targets.

The sensory and imaginative immersion during the game scored somewhere between fairly and extremely on average. 5 out of 8 participants were fairly interested in the game's story, 4 of the respondents found it extremely aesthetically pleasing and four felt fairly imaginative. Moreover, 5 out of 8 participants extremely felt that they could explore things, 4 respondents found it fairly impressive, and 5 people felt extremely as if it was a rich experience.

The flow of the game on average was fairly rated. 7 people out of the total 8 participants felt extremely occupied with the game, 4 respondents felt fairly that they forgot everything around them and 3 fairly lost track of time. Furthermore, 6 of the participants fairly felt deep concentration during the game, and 4 fairly lost connection with the outside world.

The tension and annoyance during the game were expressed as not experienced at all on average. 7 out of 8 participants felt not at all annoyed, 6 participants felt not at all irritable and 5 felt not at all frustrated.

The participants felt fairly challenged during the game on average. However, 4 of the participants felt extremely challenged. Moreover, 3 out of 8 people felt moderately that they had to put a lot of effort into the game and 3 not at all, 3 slightly felt pressured. Furthermore, 3 of the respondents moderately thought it was hard and 3 participants felt extreme time pressure.

The negative affect during the game showed to be presented on a "not at all" average level meaning it was near to 0. All the 8 participants of the testing felt that the game gave not at all a bad mood, 4 of the participants moderately thought about other things during the game, 5 people not at all found it tiresome and 7 not at all felt bored.

When it comes to the positive affect of the game, the average rate points out an extremely satisfactory score. 4 of the total 8 participants felt extremely content or satisfied, 7 of the respondents thought it was extremely fun, 4 people fairly felt happy, 5 felt extremely good and 7 extremely enjoyed it.

Moreover, 7 additional items were added to the standardized GEQ which were focusing on engagement and educational purposes of the game [18]. Some of the items measure the amount of motivation [55], desire to continue playing [3], relatedness and autonomy during the game as they characterize engagement according to researchers [34, 51]. 5 out of the 8 participants felt extremely engaged during the game, 4 people felt fairly motivated, 5 respondents felt fairly a desire to continue playing, 4 people felt moderately related to the game and 2 people had not at all, slightly, moderately, fairly intrinsic and self-defined goals.

Also, items measuring the eagerness and the encouragement for learning throughout the game in regard to educational purposes have been evaluated. 4 of the participants felt extremely eager to learn while 5 of the respondents felt extremely encouraged to learn during the game.

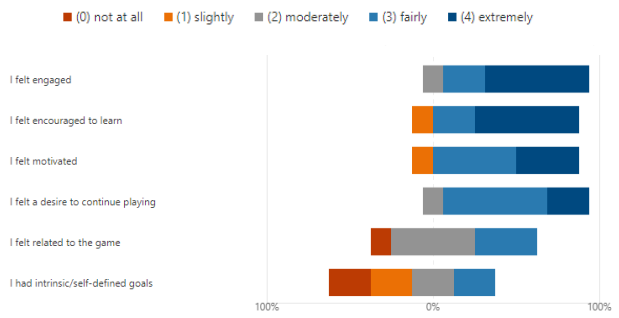



**Figure 26. The results visualize the added items on engagement and educative purposes**

**Post-usability interviews**

Interviews are excellent complementary techniques to observation or after an activity especially before and after a user test [33]. I chose to conduct interviews after the user testing with the aim of getting a better understanding of the participants' museum experience during the treasure hunt. The aim was to make them reflect on their experiences on a deeper level also in regard to engagement and the educational purposes of the game. A predefined protocol was followed with five main questions with some follow-up questions (see *Appendix 2.*). The interviews took place online the day of- or the day after testing. One interview was about 30 minutes long, giving a rich background and complementary data for the post-usability questionnaires. After conducting the interviews and transcribing them a thematic analysis was proceeded highlighting numerous categories and insights [8].

*Results from the post-usability interviews*

Overall, the results from the thematic analysis of the post-interviews show a positive tone towards the treasure hunt and its usage in a museum environment. All the participants expressed their engagement during the game and that it helped to focus and to interact within the exhibition. Moreover, the good information and interesting questions have been pointed out by all the participants as well. The game was clear and had a natural flow according to 7 out of the 8 participants with presenting first a riddle, then giving the opportunity for a hint followed by a question which could result in clues and points before getting to guess for the treasure. One of the participants even said: " *I also forgot that it was a prototype for a moment.*" The amount of 5 questions were experienced just good in order to steer the attention and highlighted interesting paintings without the overwhelming feeling according to 6 participants. The other two participants would have tried some more riddles as well since they were having an immersive and fun experience which they would have wished to continue a little longer. However, one of the participants drew attention to an important aspect in regard to inclusive design: "*Also, I have dyslexia so I have a hard time reading longer pieces of texts... So I was thinking I often feel stupid when there is a lot of text. But I didn't feel it..it was short and concise..so I could understand.*"

Even though the majority (7) of the participants tried to solve the riddles without hints in the first place when hints were used they gave clear guidance and directions according to the participants of the test. The treasure hunt with its questions, hints, and clues wasn`t experienced too easy, as it encouraged thinking and even some external knowledge. Also, three participants acknowledged that humor and storytelling were encouraging throughout the game. One of the participants described the overall feedback as: "*I was expecting it to be fun and good but it was even better than I thought it would be.*" Furthermore, the treasure hunt made the participant an active part of the exhibition, by making them look more, read more, engage more. Compared to the experience of usual museum exhibitions, playing treasure hunt during a museum visit created a different museum experience, where the participants had a purpose within the exhibition. It has been expressed by 5 out of 8 participants that they usually read only about the paintings which interest them. Meanwhile, this treasure hunt made them read and engage more since the goal of the game motivated them to search for information and remember the gathered information to be able to answer the questions. Moreover, even though classic art is not something that interested everyone (3 out of 8) it has been emphasized that the treasure hunt fitted for art exhibitions as art is philosophical and open for interpretations.

As 7 out of 8 participants articulated that they usually go together with someone to museum visits, the social factor and going in pairs along the exhibition was experienced as something positive by the majority. All the pairs discussed every question together and were working in pairs except one pair which got separated as each of them used their own phone and wanted to explore the exhibition at their own speed. Moreover, this pair and two other participants have pointed out the willingness of having their own phone while playing, while the other two have mentioned that it didn`t bother them to share a phone during the game. However, 3 of the participants would prefer to play the game alone, 2 don't think they would do it by themselves and 3 of them could imagine doing it alone just as well together with someone. The reason behind why some would prefer playing the game alone is partly because the award of the game is not shared and partly because of the freedom factor, to be able to explore the exhibition in their own phase, only examining the artifacts of their own interest without the need of waiting in others which otherwise would cause small irritation moments. To highlight the different opinions, as one of the participants articulated it:

*"I think I would prefer it alone because doing it together takes away from the freedom aspect of it. I think usually when I go to museums it can be a brag sometimes to deal with other people because they want to look at different pictures or different stuff and they are not interested in the things that you are interested in and then you both spend the time waiting for each other looking at things you are not really interested in."*

While another participant talked about the game as social company:

*"Yeah, I would use it alone as well. Because I used to go to exhibitions and museums alone, and I think it's kind of fun because it kind of gets you more engaged and you feel like you are not alone through the exhibition. It kind of like almost gives you something to discuss the paintings with while you are technically doing it."*

When it comes to the experience of two groups playing at the same time, 3 of the participants expressed that they felt a competitive vibe during the testing with the other group. While 4 others didn't think about the other group that much and only one of the test persons said that she felt as if all of them were playing together. Also, 2 participants expressed that it would be fun to interact with strangers during the game.

The main motivation was the clues to be collected and the treasure for the participants. However, the game itself seems to be the most motivating factor above all according to the interviews. Even though the ticket as an award was an appealing factor, it was surprising and not expected (5 out of 8). To learn something new and gather interesting information in the form of the game was motivating everyone enough to think about downloading the game. Most of the participants were not familiar with who Anders Zorn was before the exhibition and learned quite a lot about him and his work by the game. However, it is questionable how much of that information would have reached them without the game only reading the descriptions or listening to the audio guides. The goal of the game and the purpose of the visit helped in learning according to the groups. It made them reflect, pay attention to details and read more about the interesting paintings. The majority of the participants said that they remember things that usually they don't pay attention to. Moreover, each and one of them could recognize some paintings which were part of the game and were able to recall some background information about them. It was interesting that some (6 out of 8) remembered the answers that they got right while some (2 out of 8) remembered more easily those that they guessed wrong. Also, they could recall further information about other paintings and information which were not part of the game as well. As one of the participants said: "*This is the best way for me to learn new things. I don't ever learn so much if it is not connected to something exciting.*"

The participants agreed that it would be fun to do it again. Even if it suits art exhibitions, it could have been fun to do it over the whole museum according to 3 of the participants. The only time someone expressed that she would not do it, would be if she would have limited time to visit an exhibition. The lack of time made the experience a bit stressful and the fact that the exhibition couldn`t be freely explored for at least 6 of the participants. However, it is only a limitation in regard to the testing circumstances. At the same time, there were some considerations regarding the game such as that it would have been interesting to get to know the right answer after a wrong guess or at least retry to find the treasure. Nevertheless, it was surprising but not something necessarily negative that some of the questions required external knowledge.

All of the participants agreed with the following statement: "Treasure hunt games create a more engaging experience of exhibitions because of gamification and educative content." As gamification motivated users to learn in this specific treasure hunt, and as there is always something in gamification for everyone according to the testers it was accepted to be true. Also, this particular treasure hunt made the whole visit more engaging and fun for everyone. However, one of the participants highlighted that engagement depends on the questions, the treasure, and the design of the game itself.

Future ideas, such as different target groups and levels within the treasure hunt were articulated by 3 of the participants. Whereas teenagers were especially emphasized to be an interesting target group as they are naturally expecting a digital experience and have less of an interest in museums, even if they do have some obligatory visits with schools and then why not make it more fun but also educational. Another future implementation idea was about the presentation of the tasks: "*Also, it would have been really awesome to be able to listen to the questions and answers something like the audiobooks. You could maybe listen to the information cards while playing the game. That would be really nice.*" Furthermore, the audio experience's inclusive design elements were articulated as well for people who can not read or see, making the game a supportive tool.



**Figure 27. Thematic analysis of the interviews in Miro (2021)**

## LIMITATIONS

### Pre-study questionnaire

There have been a couple of limitations during the project which caused dilemmas. Regarding the pre-study with the online questionnaires, the access to visitors of the Nationalmuseum and especially to users of the Nationalmuseum Visitor Guide application was very limited. Even if the Nationalmuseum was collaborating a lot, to spread the questionnaires on the Nationalmuseum's own news channels was not an option which made it harder to access their users. However, in the threads of the Nationalmuseum Facebook group I was able to comment and attach the surveys. Unfortunately, the surveys commented in the Facebook threads of the Nationalmuseum have not resulted in as many answers as expected and therefore the answers in regard to the Nationalmuseum itself were limited. Even though, I would not say it affected much of the study since museum visitors, in general, are the target group of the Nationalmuseum as well.

One of the biggest dilemmas was about the testing and the evaluation methods of the prototype due to the current pandemic situation caused limitations in regard to regulations in public places such as in museums. Luckily, a temporary exhibition opened up in the Nationalmuseum for the public in April and since the results of the survey highlighted the interest in interacting with artifacts from a selected exhibition this became possible to test. Even though the possibility to choose from exhibitions became

very limited. In normal circumstances, the prototype would have targeted the permanent exhibition of the Nationalmuseum, but that was not an option as it only opened later.

### Testing

The fact that the testing needed to be done before visiting hours and only under an hour added a stress factor. The user tests were conducted in the early mornings from 8 to 9, but the time limit and the feeling of being overwatched affected the testers' experience. For security reasons, one of the museum workers needed to be there to watch over us and keep us moving across the same rooms. This caused limitations in regard to exploring the exhibition freely as all the four participants needed to wait for each other before they could have moved on to the next room for the next riddle. Also, the fact that there was no possibility to check out the exhibition beforehand and do a pilot test led to difficulties as well. The order of the paintings in the riddles was not following the order of the paintings as they were exhibited in the rooms. This was problematic because after the first two riddles everyone needed to be led to the last room of the exhibition and then back to the beginning again. During the first testing, it meant much more frustration as it was the first time being in the exhibition without knowing exactly where the paintings were at. The exhibition was quite big, but with the help of the museum worker, the groups were led to the right rooms even though it was a stressful factor, because of the limited time we had. However, after the first testing, the next session went more smoothly the day after knowing from the beginning where to go.

The lack of time between the testings made it hard to iterate on the prototype. It would have been good to do some changes in regard to the order of the riddles before the second testing. However, as the prototype was made out of a 2200 screen design, changing the order would have meant changing all the interactions in each screen. As it would have been a time-consuming procedure, the prototype remained the same for the second testing. Even though for the sake of constant and comparable test results it was better not to make any changes in the prototype.

### Evaluation

Furthermore, the evaluation of the post-usability questionnaire had some limitations as well. The Game Experience Questionnaire (GEQ) is usually evaluated together with "basic psychometric data from researchers, such as Cronbach's α, ideally including other indicators of reliability such as omega" which in this study was not presented [27]. However, additional variables were added to the core formula in order to analyze the experience in regard to engagement and the educational purpose as the main focus of this study. Since there is no clear method set for evaluating the GEQ as to modify the items recommended as part of an iterative process by the founders of the questionnaire [18], the evaluation by looking at the mode value in each category was done. Moreover, factor analysis to investigate the structure of the scale within the chosen sample was barely done. However, as highlighted in the study by Law et al. [27] the GEQ and the exploratory factor analysis require a large number of participants to be reliable. As this post-usability survey was conducted on only 8 respondents the small sample size does not require such a detailed evaluation method and therefore the GEQ chose to be considered as a guideline. Through the GEQ with additional items, the different factors affecting game experience during the treasure hunt were presented and analyzed descriptively by each category.

## DISCUSSION

The results of the user study showed that a game within a museum application is affecting the museum experience regarding engagement and for the purpose of learning on different levels. Based on the findings of this study, this section will present important parts to be considered when it comes to creating engaging museum experiences within an exhibition focusing on a museum application in relation to the theoretical frameworks and relevant research.

### Game mechanics, dynamics, and emotions

Looking at the user experience of the designed treasure hunt game within the exhibition from the perspective of the MDE gamification framework some interesting findings can be mentioned [52]. The team-based player structure in the sense that the groups were divided into two pairs resulted partly in competitive dynamics between the groups (3 out of 8 participants). However, since the tasks were given in groups of two the majority did not bother about the other team, only their own (4 out of 8 participants). Also, it was interesting that even though there were no multiplayer components in the game one of the participants felt like all of them were playing together, meaning a cooperative dynamic. Even though it is important to highlight that two of the participants in the study who had access to their own phones split up and followed their own path as the prototype was based on individual mechanics, made it possible to play the game alone as well in case each member from the pairs had their own phone. It was interesting to observe that even if these two participants were basically playing the game alone, they still communicated along with the treasure hunt: "*When I found a painting, I went to my friend so it was not like I kept it to myself and he told me too when he found something so it was a little bit like a collaboration."* This example showed how individual player structure mechanics may result in cooperative dynamics instead of a competitive one which goes along with LeBlanc's [19] statement as game dynamics are hard to predict. Also, this game dynamic emerged during the game by the users which resulted in shaping the game mechanics and an optimized gamified experience [52].

Moreover, cooperative dynamics provoked positive emotions. Emotions such as excitement, curiosity, and joy were most commonly mentioned during the follow-up interviews. The fact that during the user testing in one of the groups people didn't know each other while in the other group people did, showed no effect or any differences in regard to how engaged the participants were and how much they learned throughout the experience. However, sharing a phone versus having an own phone to play on has shown

some differences in game dynamics and emotions. It was very subjective whether people liked to share a phone to collaborate on (5 out of 8) or rather would have liked to experience the treasure hunt game on their own phone (3 out of 8). Even though, overall, the participants liked to play together as many of them (6 out of 8) felt that they learned both from each other and the game. Therefore, the setup mechanics for most cases (for 6 out of 8 participants) resulted in cooperative dynamics [52]. This corresponds to the result of Tsai and Sung's study [59] in which mobile games enhance the social effect between the museum visitors. Moreover, the authors state that it provides a more immerse learning experience which has been also shown during this study.

**Learning throughout the treasure hunt**

The objective-based and progression rule mechanics [10] through the riddles and unlocking clues motivated the users to reach the goal of the game, but also to gather as much information as possible. In order to reach the goal of the game to find Zorn's treasure the users of the treasure hunt needed to focus on the information provided within the exhibition. Thus, the users were "forced" to pay attention to details and learn some new information about the painter and his work which might have been overlooked otherwise. As one of the participants said: *"To find something, I had to search for it and read the descriptions which I would not do if I would just go around the exhibition".* It can be argued that a gamified learning environment such as the museum exhibition with a treasure hunt is an effective way of learning new information while having an enjoyable experience [43]. Even if this treasure hunt had the objective of locating different paintings in an exhibition, the museum visitors were still able to interact with the prototype within the exhibition in a way that made them think, reflect as it provided a learning experience [59]. The results of the post-usability questionnaire just as the interviews indicate this as well. In the post-usability questionnaire, 4 of the participants answered that they felt extremely eager to learn and 5 of the respondents felt extremely encouraged to learn during the treasure hunt game. Moreover, it became clear during the interviews that learning, reading about fun facts, and interesting information was a motivation for many of the participants (for 5 out of 8). As one of the participants highlighted: "*I think the learning thing maybe might be the most motivating for me."*

Furthermore, all of the participants could recall something that they learned about almost each painting within the game and they even remembered some additional information about the artist and his works that were not part of the game. This proves that the game mechanics resulted in accomplishments for the purpose of learning as well.

**Engagement during the treasure hunt**

The Process-oriented player engagement framework has been used as a crucial part together with the Gamification framework already from the beginning of the ideation process to ensure engagement [55]. Besides the previously mentioned accomplishments, some other ones can be named in regard to the game together with objectives, activities, and affect. The objectives within the treasure hunt during the museum visit succeeded in both extrinsic and intrinsic levels as the participants were triggered by the given challenges in the forms of riddles, but also were motivated to explore on their own. In order to reach these objectives activities such as socializing, solving, sensing, experiencing the story and characters, exploring, experimenting were presented during the user tests. Even though some activities were more present than the others. Some of the participants would have liked to spend more time exploring and sensing the art. As one of the participants expressed: *"Also, it would have been really awesome to be able to listen to the questions and answers because I really like the audiobook feeling."* This highlights the interest in multimodal experiences as an additional aspect of the engagement.

As the result of the activities, the accomplishments in the forms of achievements, progression and completion were presented in the game which aligns with Schoenau-Fog's framework [55]. The biggest achievement was to find Zorn's treasure, however, the participants were engaged mostly through collecting the clues and solving the riddles. As one of the participants expressed, the fear of losing clues was also motivating: "*With the main clues it was more surprising, you felt like something was at stake.. that you actually had consequences to not getting the answers right."* It was interesting to see that the virtual goods, badges, and points as important game components [61] were not as motivating as to find the treasure itself and to prove themselves. One of the participants highlighted it as follows: *"I think in the beginning you got so excited you like, you wanna approve yourself right without having any hints."*

The positive and negative affect throughout the game was triggered by giving points and clues in case of right answers. However, the majority of the participants weren't affected by the points so much, neither as they expected an award in the end but were mostly motivated by the "affect" of absorption throughout the game. As one of the participants articulates this well: "*The game sort of just took over and I did it for the joy of doing it."*

Moreover, as the evaluation of the post-usability questionnaire pointed out the sensory and imaginative immersion during the game scored high, somewhere between fairly and extremely on average. However, the flow was fairly rated on average just as in the case of challenge and competence. There was almost no negative effect, tension, and annoyance, but an extremely satisfying score in regard to the positive affect on an average. Overall, 5 out of the 8 participants felt extremely engaged during the game based on the results from the post-study.

According to Schoenau-Fog [55], by using the Process-oriented player engagement framework, engagement as a process can be explained. Therefore, it can be stated that during the designed treasure hunt game within the exhibition of Zorn Anders, the players engaged in a pursuit of objectives both given by the game but within the exhibition itself as well and consequently performed a range of activities in the forms of riddles in order to accomplish the goal of the game but also to feel an effect of absorption.

## CONCLUSION

This study was built around and investigated the research question: *How can an engaging museum experience be created with a game in a museum application in order to educate visitors in a more interactive and fun way?* Through empathizing with the museum visitors' need in regard to museum experiences focusing on games and museum applications it became clear that a treasure hunt game could be a promising choice for creating engagement just as well offer educative content during a museum visit. Based on crucial theoretical frameworks [52, 55] and relevant literature combined with inspiration from previous examples of museum games, a treasure hunt was created and implemented into the Nationalmuseum' application in the form of an interactive prototype. After testing the prototype with eight participants in a museum environment (Anders Zorn temporary exhibition at the Nationalmuseum) conclusions could be drawn based on the evaluation methods (observation, post-usability questionnaire, and interviews). The findings showed that a treasure hunt game that provides fun facts and interesting content which makes the users think and explore can be an appropriate way to create engagement and educate within an exhibition. The game "Zorn`s treasure" was a fine example of such a game according to the participants of the usability tests. Even though this study was focusing on the case study of the Nationalmuseum the results in regard to successful game mechanics and components in relation to engagement and for the purpose of learning can contribute to future work of any treasure hunt game being designed within a museum exhibiting artifacts. Some of the key findings were that short challenges in form of quests or riddles with some elements of randomness (fun facts, hints, interesting questions) which encourage the users to think on a deeper level motivate players to achieve the objective of the game while it makes them engage and learn. Giving clues to the users showed a great impact on engagement as well since players were more excited to accomplish the tasks and pay attention more thus it made them learn intentionally or unintentionally. The game was described as a "useful tool" by the participants which give information, clear guidance, and directions. Moreover, the topics touched upon in the discussion can be useful for further guidelines as well as for shaping design principles for future works.

Player engagement is understood in this study as a strong level of desire to continue playing in order to learn and achieve a goal while it evokes emotions that contribute to individual development. It can be argued that the designed treasure hunt succeeded to fulfill these criteria and created engagement as based on the post-usability questionnaire the participants of the study felt a desire to continue playing in order to get to know more about the hidden facts which lead to the treasure [3]. Moreover, the participants were motivated by the given challenges [11], to gather information while they were having fun [24]. Also, the fact that the user tests were conducted within groups showed that the majority favored sharing this game experience with someone else and that the social factor was affecting the engagement level as well as evoked emotions. I believe that the results of this study will contribute not only to Nationalmuseum's future implementations but to future work in this field to create more engaging museum experiences in the form of games.

## REFERENCES


1. Raed S. Alsawaier. 2018. *The effect of gamification on motivation and engagement.* The International Journal of Information and Learning Technology 35, 1 (January 2018), 56–79. DOI:https://doi.org/10.1108/IJILT-02-2017-0009

2. Emily Brown and Paul Cairns. 2004. *A grounded investigation of game immersion.* In CHI '04 Extended Abstracts on Human Factors in Computing Systems (CHI EA '04). Association for Computing Machinery, New York, NY, USA, 1297–1300. DOI:https://doi.org/10.1145/985921.986048

3. Stuart Brown and Christopher Vaughan. 2009. *Play: How it Shapes the Brain, Opens the Imagination, and Invigorates the Soul* (Avery Publishing Group ed.). Penguin, New York, NY.

4. U. Biader Ceipidor, C. M. Medaglia, V. Volpi, A. Moroni, S. Sposato, M. Carboni, and A. Caridi. 2013. *NFC technology applied to touristic-cultural field: A case study on an Italian museum.* In 2013 5th International Workshop on Near Field Communication (NFC), IEEE, Zurich, Switzerland, 1–6. DOI:https://doi.org/10.1109/NFC.2013.6482445

5. Brigid Costello and Ernest Edmonds. 2009. *A tool for characterizing the experience of play.* In Proceedings of the Sixth Australasian Conference on Interactive Entertainment (IE '09). Association for Computing Machinery, New York, NY, USA, Article 2, 1–10. DOI:https://doi.org/10.1145/1746050.1746052

6. John W. Creswell and J. David Creswell. 2018. *Research design: qualitative, quantitative, and mixed methods approaches* (Fifth edition). SAGE, Los Angeles.

7. Lynn D. Dierking and John H. Falk. 1992. *Redefining the museum experience: the interactive experience model*. Visitor Studies 4, 1 (1992), 173–176.

8. Scott Doorley, Sarah Holcomb, Perry Klebahn, Kathryn Segovia, and Jeremy Utley. 2018. *Design Thinking Bootleg.* Stanford d.school. Retrieved May 26, 2021 from https://dschool.stanford.edu/resources/design-thinking-bootleg

9. Maria Economou and Elpiniki Meintani. 2011. *Promising beginnings? Evaluating museum mobile phone apps.* In Evaluating Museum Mobile Phone Apps. Rethinking Technology in Museums 2011: Emerging experiences, University of Limerick, Ireland, 20. Retrieved from http://www.idc.ul.ie/techmuseums11/

10. Christian Elverdam and Espen Aarseth. 2007. *Game Classification and Game Design: Construction Through Critical Analysis.* Games and Culture 2, 1 (January 2007), 3–22. DOI:https://doi.org/10.1177/1555412006286892

11. Laura Ermi. 2005. *Fundamental Components of the Gameplay Experience: Analysing Immersion.* DIGRA (May 2005). Retrieved May 25, 2021 from https://ir.lib.sfu.ca/item/260

12. Experiments with Google. *Play with Arts & Culture*. 2020. Retrieved May 26, 2021 from https://experiments.withgoogle.com/collection/play-with-arts

13. John H. Falk and Lynn D. Dierking. 2016. *The Museum Experience Revisited*. Routledge.

14. Christina Goulding. 2000. *The museum environment and the visitor experience.* European Journal of Marketing 34, 3/4 (January 2000), 261–278. DOI:https://doi.org/10.1108/03090560010311849

15. Sam Grobart. 2011. *Multimedia tour guides on your smartphone*. The New York Times 16, (2011).

16. Benjamin Hanussek. 2020. *Enhanced Exhibitions? Discussing Museum Apps after a Decade of Development*. Adv. archaeol. pract. 8, 2 (May 2020), 206–212. DOI:https://doi.org/10.1017/aap.2020.10

17. Johannes Harms, Christoph Wimmer, Karin Kappel, and Thomas Grechenig. 2014. *Gamification of online surveys: conceptual foundations and a design process based on the MDA framework*. In Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational (NordiCHI '14). Association for Computing Machinery, New York, NY, USA, 565–568. DOI:https://doi.org/10.1145/2639189.2639230

18. Wouter M. van den Hoogen, Wijnand A. IJsselsteijn, and Yvonne AW de Kort. 2008. *Exploring behavioral expressions of player experience in digital games.* In Proceedings of the workshop on Facial and Bodily Expression for Control and Adaptation of Games ECAG, Citeseer, Amsterdam, The Netherlands, 11–19.

19. Robin Hunicke, Marc LeBlanc, and Robert Zubek. 2004. *MDA: A formal approach to game design and game research.* In Proceedings of the AAAI Workshop on Challenges in Game AI, San Jose, CA, Retrieved from https://www.aaai.org/Papers/Workshops/2004/WS-04-04/WS04-04-001.pdf

20. Steven Issacs. 2015. *The Difference between Gamification and Game-Based Learning*. Retrieved April 26, 2021 from https://inservice.ascd.org/the-difference-between-gamification-and-game-based-learning/

21. Filomena Izzo. 2017. *Museum Customer Experience and Virtual Reality: H.BOSCH Exhibition Case Study.* Modern Economy 08, 04 (2017), 531–536. DOI:https://doi.org/10.4236/me.2017.84040

22. Charlene Jennett, Anna L. Cox, Paul Cairns, Samira Dhoparee, Andrew Epps, Tim Tijs, and Alison Walton. 2008. *Measuring and defining the experience of immersion in games.* International Journal of Human-Computer Studies 66, 9 (September 2008), 641–661. DOI:https://doi.org/10.1016/j.ijhcs.2008.04.004

23. Alice Keeler. 2014. *Beyond the Worksheet: Playsheets, GBL, and Gamification.* Edutopia. Retrieved June 5, 2021 from https://www.edutopia.org/blog/beyond-worksheet-playsheets-gbl-gamification-alice-keeler

24. Christoph Klimmt. 2003. *Dimensions and determinants of the enjoyment of playing digital games: A three-level model.* In Level up: Digital

games research conference, University of Utrecht & DiGRA, Utrecht, Netherlands, 246–257.

25. Raph Koster. 2004. *Theory of Fun for Game Design.* 244. Scottsdale, AZ: Paraglyph Press.

26. Kelvin Kristianto, Kerin Dela, and Handri Santoso. 2018. *Implementation of Gamification to Improve Learning in Museum.* JESR 2, 1 (February 2018), 71–76. DOI:https://doi.org/10.26666/rmp.jesr.2018.1.11

27. Effie L.-C. Law, Florian Brühlmann, and Elisa D. Mekler. 2018. *Systematic Review and Validation of the Game Experience Questionnaire (GEQ) - Implications for Citation and Reporting Practice*. In Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play, ACM, Melbourne VIC Australia, 257–270. DOI:https://doi.org/10.1145/3242671.3242683

28. Daniel Le Berre, Pierre Marquis, and Stéphanie Roussel. 2013. *Planning personalised museum visits.* In Proceedings of the International Conference on Automated Planning and Scheduling, PKP Publishing Services Network, Lens, France.

29. Shi-Ying Li. 2017. *The Development of Museum APPs and its Solutions*. Journal of Huizhou University, China. (4).

30. Shunli Liu and Muhammad Zaffwan Idris. 2018. *Constructing a framework of user experience for museum based on gamification and service design.* MATEC Web Conf. 176, (2018), 04007. DOI:https://doi.org/10.1051/matecconf/201817604007

31. Matthew Lombard and Theresa Ditton. 2006. *At the Heart of It All: The Concept of Presence.* Journal of Computer-Mediated Communication 3, 2 (June 2006). DOI:https://doi.org/10.1111/j.1083-6101.1997.tb00072.x

32. Alejandro López-Martínez, Álvaro Carrera, and Carlos A. Iglesias. 2020. *Empowering Museum Experiences Applying Gamification Techniques Based on Linked Data and Smart Objects*. Applied Sciences 10, 16 (August 2020), 5419. DOI:https://doi.org/10.3390/app10165419

33. Stephanie Marsh. 2018. *User research: a practical guide to designing better products and services*. KoganPage, London.

34. Paul F. Marty. 2007. *Museum Websites and Museum Visitors: Before and After the Museum Visit.* Museum Management and Curatorship 22, 4 (December 2007), 337–360. DOI:https://doi.org/10.1080/09647770701757708

35. John McCarthy and Peter Wright. 2004. *Technology as experience.* interactions 11, 5 (September 2004), 42–43. DOI:https://doi.org/10.1145/1015530.1015549

36. Catherine McEver. 2001. *Electronic Guidebook Forum*. Exploratorium, San Francisco, California. Retrieved June 5th, 2021 from: https://www.exploratorium.edu/guidebook/forum_report.pdf

37. Sandra Medic and Natasa Pavlovic. 2014. *Mobile technologies in museum exhibitions.* Turizam 18, 4 (2014), 166–174. DOI:https://doi.org/10.5937/Turizam1404166M

38. Nationalmuseum. 2019. *Nationalmuseum Visitor Guide Evaluation.* Stockholm, Sweden.

39. Nationalmuseum. 2019. *Årsredovisning 2019.* Retrieved June 5, 2021 from https://www.nationalmuseum.se/assets/Dokument/%C3%85rsredovisning-2019.pdf

40. Nationalmuseum. 2021. *About Nationalmuseum*. Retrieved June 4, 2021 from https://www.nationalmuseum.se/en/om-nationalmuseum

41. Basanth Kumar Neeli. 2015. *Gamification in the Enterprise: Differences from Consumer Market, Implications, and a Method to Manage Them*. In Gamification in Education and Business, Torsten Reiners and Lincoln C. Wood (eds.). Springer International Publishing, Cham, 489–511. DOI:https://doi.org/10.1007/978-3-319-10208-5_25

42. Scott Nicholson. 2015. *A RECIPE for Meaningful Gamification.* In Gamification in Education and Business, Torsten Reiners and Lincoln C. Wood (eds.). Springer International Publishing, Cham,

1–20. DOI:https://doi.org/10.1007/978-3-319-10208-5_1

43. Ioannis Paliokas and Stella Sylaiou. 2016. *The Use of Serious Games in Museum Visits and Exhibitions: A Systematic Mapping Study*. In *2016* 8th International Conference on Games and Virtual Worlds for Serious Applications (VS-GAMES), IEEE, Barcelona, Spain, 1–8. DOI:https://doi.org/10.1109/VS-GAMES.2016.7590371

44. Federica Palumbo, Gandolfo Dominici, and Gianpaolo Basile. 2013. *Designing a mobile app for museums according to the drivers of visitor satisfaction.* In Recent Advances in Business Management and Marketing-Proceedings of the 1st International Conference on Management, Marketing, Tourism, Retail, Finance and Computer Applications (MATREFC'13). Dubrovnik, Croatia, WSEAS Press.

45. Sara Perry, Maria Roussou, Maria Economou, Hilary Young, and Laia Pujol. 2017. *Moving beyond the virtual museum: Engaging visitors emotionally*. In 2017 23rd International Conference on Virtual System & Multimedia (VSMM), IEEE, Dublin, 1–8. DOI:https://doi.org/10.1109/VSMM.2017.8346276

46. Danilo Pesce, Paolo Neirotti, and Emilio Paolucci. 2019. *When culture meets digital platforms: value creation and stakeholders' alignment in big data use.* Current Issues in Tourism 22, 15 (September 2019), 1883–1903. DOI:https://doi.org/10.1080/13683500.2019.1591354

47. Karolien Poels, Yvonne De Kort, and Wijnand IJsselsteijn. 2007. *D3.3 : Game Experience Questionnaire: development of a self-report measure to assess the psychological impact of digital games.* Technische Universiteit, Eindhoven. (2007).

48. Andrew K. Przybylski, C. Scott Rigby, and Richard M. Ryan. 2010. *A Motivational Model of Video Game Engagement*. Review of General Psychology 14, 2 (June 2010), 154–166. DOI:https://doi.org/10.1037/a0019440

49. Ludwig Qvarnström. 2018. *Swedish art history: a selection of introductory texts*. Lund University Press, Lund.

50. Boa Rhee and Yongsoon Choi. 2015. *Using Mobile Technology for Enhancing Museum Experience: Case Studies of Museum Mobile Applications in S. Korea.* IJMUE 10, 6 (June 2015), 39–44. DOI:https://doi.org/10.14257/ijmue.2015.10.6.05

51. Scott Rigby, Richard M. Ryan. 2011. *Glued to games: how video games draw us in and hold us spellbound.* Choice Reviews Online 49, 01 (September 2011), 49-0099-49–0099. DOI:https://doi.org/10.5860/CHOICE.49-009

52. Karen Robson, Kirk Plangger, Jan H. Kietzmann, Ian McCarthy, and Leyland Pitt. 2015. *Is it all a game? Understanding the principles of gamification.* Business Horizons 58, 4 (July 2015), 411–420. DOI:https://doi.org/10.1016/j.bushor.2015.03.006

53. Umar Ruhi. 2015. *Level Up Your Strategy: Towards a Descriptive Framework for Meaningful Enterprise Gamification.* Technology Innovation Management Review 5, 8 (2015), 12.

54. Jeff Sauro and James R. Lewis. 2016. *Quantifying the User Experience: Practical Statistics for User Research* (2nd ed.). Morgan Kaufmann.

55. Henrik Schoenau-fog. 2011. *The Player Engagement Process – An Exploration of Continuation Desire in Digital Games*. Eludamos: Journal for Computer Game Culture, 6(1), 53–70.

56. Dan Scott. 2018. *The Zorn Palette – What It Is And How You Can Use It*. Draw Paint Academy. Retrieved May 26, 2021 from https://drawpaintacademy.com/zorn-palette/

57. Nina Simon. 2010. *The Participatory Museum*. Museum 2.0.

58. Loïc Tallon and Kevin Walker. 2008. *Digital Technologies and the Museum Experience: Handheld Guides and Other Media*. Rowman Altamira.

59. Henry Tsai and Kelvin Sung. 2012. Mobile Applications and Museum Visitation. *Computer*

45, 4 (April 2012), 95–98.
DOI:https://doi.org/10.1109/MC.2012.143

60. Useeum. *The Museum Mystery | Useeum - One app for all museums*. Retrieved June 5, 2021 from https://useeum.com/the-museum-mystery/

61. Kevin Werbach and Dan Hunter. 2012. *For the Win: How Game Thinking Can Revolutionize Your Business*. Wharton Digital Press.

62. Mark J.P. Wolf and Bernard Perron. 2013. *The Video Game Theory Reader* (1st ed.). Routledge, New York.
DOI:https://doi.org/10.4324/9780203700457

63. Nick Yee. 2006. *Motivations for Play in Online Games.* CyberPsychology & Behavior 9, 6 (December 2006), 772–775.
DOI:https://doi.org/10.1089/cpb.2006.9.772

64. #MetKids. *The Metropolitan Museum of Art, i.e. The Met Museum*. Retrieved May 26, 2021 from http://www.metmuseum.org/art/online-features/metkids

**APPENDIX**

**Appendix 1: Pre-study questionnaire questions**

*General information*

1. How old are you? *
    a. Younger than 18
    b. 18 - 25
    c. 26 - 35
    d. 36 - 45
    e. 46 - 55
    f. 56 or older

2. How often do you visit museums? (in a non-pandemic situation) *
    a. every other week
    b. monthly
    c. every other month
    d. once every three months
    e. a few times a year
    f. less than once a year

3. Who would you go to a museum visit? (in a non-pandemic situation) *
    a. with company (family,friends, colleague..etc.)
    b. I go alone

4. What do you expect from a museum visit? (in a non-pandemic situation) You can select multiple alternatives. *
    a. to learn something new
    b. to relax
    c. to have an engaging experience
    d. other (fill out option)

*Museum application*

5. Have you used a museum application before? *
    a. yes
    b. no

6. What have you used it for? You can select multiple alternatives.
    a. for audio guides
    b. for finding information about the museum
    c. for navigation through the museum
    d. for entertainment (e.g.: play a game)
    e. for education to learn more about the artifacts
    f. for socialising (e.g.: like and share content)
    a. other (fill out option)

7. When would you like to use a museum application? You can select multiple alternatives. *
    a. before the museum visit
    b. during the museum visit
    c. after the museum visit
    d. I would not like to use it

8. What would you wish to do with a museum application BEFORE visiting the museum? You can select multiple alternatives. *
    a. plan my visit (check out the exhibitions within the museum)
    b. check out the museum map
    c. test how much I already know about the exhibition in a form of a game
    d. listen to audio guides
    e. save artifacts to my favorite list
    f. read more about the artifacts
    g. other (fill out option)

9. What would you wish to do with a museum application DURING the visit in the museum? You can select multiple alternatives. *
    a. plan my visit
    b. check out the map of the museum
    c. read more about artifacts
    d. save artifacts to my favorite list
    e. listen to audio guides
    f. engage more in form of a game
    g. share the experience on social media
    h. other (fill out option)

10. What would you say is the purpose of using an application AFTER your visit to the museum? You can select multiple alternatives. *
    a. read more about artifacts
    b. save artifacts to my favorite list
    c. listen to audio guides
    d. check out how much I have learned in form of a game
    e. share the experience on social media
    f. other (fill out option)

*Short games*

11. On a scale from 1 to 5 rate the following alternatives! (1= completely disagree, 5 = completely agree) *
    a. I would like to play short games individually before the museum visit to see how much I already know about the exhibitions.
    b. I would like to play short games individually during the museum visit to have a more engaging experience.

c. I would like to play short games individually after the museum visit to check out how much I have learnt from the visit.
d. I would like to play short games before the museum visit with my friends/family to see how much each of us already know about the exhibitions.
e. I would like to play short games during the museum visit with my friends/family to have a more engaging experience.
f. I would like to play short games after the museum visit with my friends/family to check out how much each of us have learnt from the visit.

12. Rate the statements on a scale of 5! (1 = completely disagree, 5 = completely agree) *
a. I would like to play a memory game to pair the artworks with the right information about them.
b. I would like to play crosswords to test my knowledge on the exhibition.
c. I would like to play a puzzle game to match together artifacts from the museum.
d. I would like to play a "spot it" game where I would need to find details in paintings which are not supposed to be there.
e. I would like to play a treasure hunt game through the app within the museum.
f. I would like to play quiz based on facts about the museum's artifacts.

13. Do you have any other preferences for the type of game which would interest you in a museum application?
free text (fill out option)

14. Which of the museum's artifacts would you like to interact with in a museum application? You can select multiple answers.*
a. artifacts from your favorite list
b. artifacts from selected exhibitions
c. artifacts from the archive of the museum
d. I would not like to interact with the artifacts
e. other (fill out option)

15. Which of the game elements do you prefer among the other elements? Rank the following game elements depending on what is more important to you when it comes to games. (Rank them by dragging the alternatives.) *
a. to be able to compete with each other
b. to be able to play together (e.g.: be in teams, multiplayer)
c. to be able to share your experience with someone (e.g.: on social media)
d. to be able to learn something
e. to play for leisure
f. to have a personal experience (e.g.: recommendations)
g. to complement real-life experience (e.g.: play games during museum visit)
h. to be able to achive a goal (e.g.: levels)
i. to have personal rewards (e.g.: digital personalized souvenirs)
j. to explore

16. Do you have any thoughts on how a game could create a meaningful museum experience?
free text (fill out option)

*Nationalmuseum, Stockholm*

17. Have you been in the Nationalmuseum in Stockholm before? *
a. yes
b. no

18. Have you used the Nationalmuseum's Visitor Guide mobile application before? *
a. yes
b. no

19. What have you used the application for? You can select multiple alternatives.
a. to check out exhibitions beforehand
b. to check the museum's map over the building
c. to listen to audio guides
d. to read more about the exhibitions
e. to search for artifacts and to add them to favorite list
f. to check out the favorite list after the museum visit
g. to use the number codes in order to get more in depth information about the artifacts
h. other (fill out option)

20. When have you used the application? You can select multiple alternatives. *
a. before the visit
b. during the visit
c. after the visit

21. Do you miss anything from the Nationalmuseum Visitor Guide application?
free text (fill out option)

**Appendix 2: Post-usability interview questions**

1. How did you like the museum experience while playing the treasure hunt game?
    a. What did you think about the riddles, hints, help, clues and questions being asked?
    b. How would you reflect on this museum experience compared to some of your previous experiences of exhibitions?
2. Did you learn anything?
    a. Can you recall something that you have learned from the exhibition?
    b. Do you think a treasure hunt game can help to remember what you have seen in an exhibition and actually make you learn from it?
3. How would you describe your experience?
    a. Can you recall a positive and a negative experience?
    b. Did you find it enjoyable to be with the other(s) during the hunt?
4. Would you like to play treasure hunt games during museum exhibits?
    a. Why?
5. Reflect on this statement: Treasure hunt games create a more engaging experience of exhibitions because of gamification and educative content
    a. What was motivating you throughout the game?
    b. What demotivated you throughout the game?

**Appendix 3: Post-usability questionnaire questions**

Please indicate how you felt while playing the game for each of the items, on the following scale: (0) not at all (1) slightly (2) moderately
(3) fairly (4) extremely

1. I felt content/satisfied
2. I felt skilful
3. I was interested in the game's story
4. I thought it was fun
5. I was fully occupied with the game
6. I felt happy
7. It gave me a bad mood
8. I thought about other things
9. I found it tiresome
10. I felt competent
11. I thought it was hard
12. It was aesthetically pleasing
13. I forgot everything around me
14. I felt good
15. I was good at it
16. I felt bored
17. I felt successful
18. I felt imaginative
19. I felt that I could explore things
20. I enjoyed it
21. I was fast at reaching the game's targets
22. I felt annoyed
23. I felt pressured
24. I felt irritable
25. I lost track of time
26. I felt challenged
27. I found it impressive
28. I was deeply concentrated in the game
29. I felt frustrated
30. It felt like a rich experience
31. I lost connection with the outside world
32. I felt time pressure
33. I had to put a lot of effort into it
34. I felt eager to learn
35. I felt engaged
36. I felt encouraged to learn
37. I felt motivated
38. I felt a desire to continue playing
39. I felt related to the game
40. I had intrinsic/self-defined goals

Component scores are computed as the average value of its items [47]. Competence: Items 2, 10, 15, 17, and 21. Sensory and Imaginative Immersion: Items 3, 12, 18, 19, 27, and 30. Flow: Items 5, 13, 25, 28, and 31. Tension/Annoyance: Items 22, 24, and 29. Challenge: Items 11, 23, 26, 32, and 33. Negative affect: Items 7, 8, 9, and 16. Positive affect: Items 1, 4, 6, 14, and 20.

Items between 34-40 were added to indicate even more engagement and the learning effect of the game.

**Appendix 4: Table of the demographics over the participants included in the usability testing**

| Group | participant | age | sex | ethnicity | phone |
|---|---|---|---|---|---|
| Group 1, pair nr. 1 | P1 | 26 | woman | Polish | with |
| | P2 | 27 | man | Hungarian | with |
| Group 1, pair nr. 2 | P3 | 25 | woman | Swedish | with |
| | P4 | 25 | woman | Lithuanian | without |
| Group 2, pair nr. 3 | P5 | 24 | woman | Swedish | without |
| | P6 | 25 | man | Swedish | with |

| | | | | | |
|---|---|---|---|---|---|
| Group 2, pair nr. 4 | P7 | 25 | man | Finnish | without |
| | P8 | 29 | woman | Swedish | with |

Group 1 - people didn’t know each other from before
Group 2 - people did know each other from before

The phone category indicates people with the prototype. In case of pair nr. 1 the participants both had the prototype and didn’t solve the tasks in pairs.