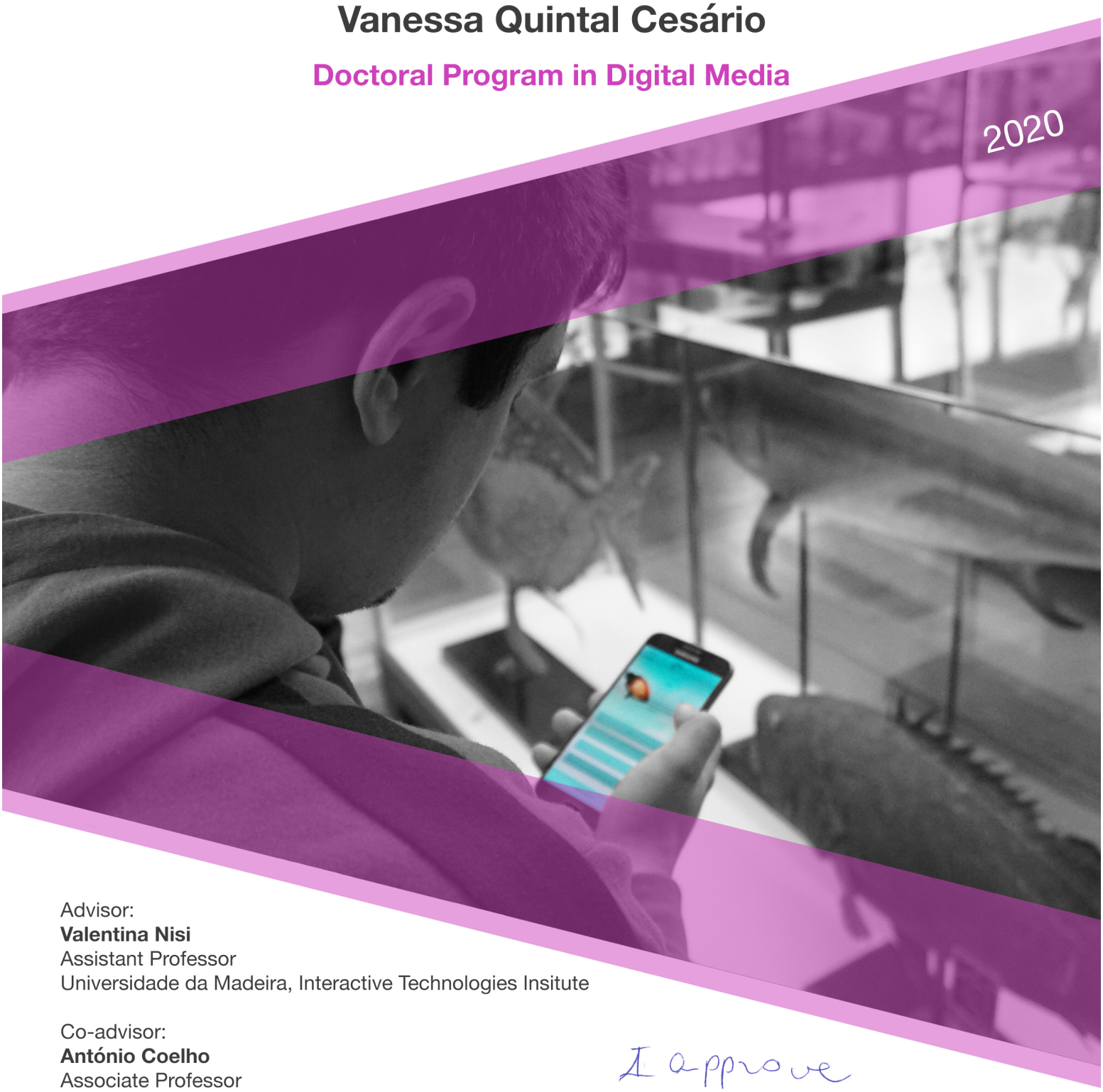
ENHANCING MUSEUM EXPERIENCES FOR TEENAGERS THROUGH GAMIFICATION AND STORYTELLING FRAMEWORKS

Vanessa Quintal Cesário

Doctoral Program in Digital Media

2020



Advisor:
Valentina Nisi
Assistant Professor
Universidade da Madeira, Interactive Technologies Insitute

Co-advisor:
António Coelho
Associate Professor
Faculdade de Engenharia da Universidade do Porto

I approve this PhD thesis document
Valentina Nisi

Cofinanciado por:

Acknowledgements

My four-year Ph.D. journey was possible through the several forms of support that I received: my scholarship, my supervisors, my research institutions, my colleagues, the researchers who collaborated with me, my internship in Sheffield, my research participants (museums and schools), my close and dearest people outside academia, and the support from my digital community in my personal blog. I acknowledge them in detail below.

First of all, I should acknowledge ARDITI (Agência Regional para o Desenvolvimento da Investigação, Tecnologia e Inovação), which awarded me with Ph.D. scholarship number M14-20-09-5369-FSE-000001 to pursue my doctorate.

I acknowledge my supervisors, Dr Valentina Nisi and Dr António Coelho, who were always available to answer my questions and give me guidance throughout my research, as well as to advise me on the best path to take. These professors always motivated me to be and do better as a researcher.

I thank my host institution, Interactive Technologies Institute (ITI), for providing me with desk space on Madeira island where I could stay while researching my topic and writing scientific articles. I also thank my university, the Faculty of Engineering of the University of Porto (FEUP), and all the people involved in the academic and administrative processes necessary to pursue the doctorate. It is certainly one of the most organised institutions that I have ever encountered. In addition, I acknowledge the funding provided by ARDITI, ITI, FEUP, and Dr Valentina Nisi, which allowed me to travel the world and present my work at international conferences on 'Human-Computer Interaction' and to be present at several editions of the following conferences: Interaction Design and Children, INTERACT, CHIPLAY, and CHI.

I acknowledge my colleagues from the universities of Porto and Lisbon, with whom I met for annual meetings focusing on the Ph.D. in Digital Media. There, we were able to share our thoughts and the results of our research studies. In addition, my lab colleagues from ITI were always there to help me when needed.

I also give special thanks to Dr Valentina Nisi, who allowed me to lead several researchers from the Sense&Tell team, with whom I produced *Memories of Carvalhal's Palace* (MoCP). My collaboration with the researchers on this team – Rui Trindade, Sandra Olim, Ana Bettencourt, Micaela Sousa, and Dina Dionísio – was invaluable to my completion of this degree. Also, in terms of this project, I acknowledge the 'Conto Contigo' theatre and 'As

Vides' restaurant for lending me costumes to use in shooting the scenes from MoCP. Moreover, I recognise the collaboration of António Reis, the voice actor.

I acknowledge Prof. Daniela Petrelli for receiving me in her Digital Materiality lab at Sheffield Hallam University and for guiding me in the analysis of my last research study. Her words and knowledge were always encouraging, allowing me to have two very productive months in the summer of 2019.

I recognise the endless support from the museums that took part in this research: the Natural History Museum of Funchal, the History of Medicine Museum at the University of Porto, and the Engineering Museum Nucleus at the University of Porto. In addition, I appreciate the schools and teachers that were willing to allow their students to be part of my research studies: Francisco Franco school, Jaime Moniz school, Ângelo Augusto da Silva school, and Santo António school.

I thank my mother, the most perfect boyfriend the world will ever see, and family. These people were always there to see the best in me and to cheer me up when I was feeling down. I also thank my close friends, who comforted and listened to me while I dealt with plenty of stress and feelings of rejection. I am astonished at how people outside academia can understand what I have experienced throughout these last four years and, best of all, be proud of what I am, not only as a person whom they can count on but also as a doctoral researcher. I acknowledge all of this fantastic emotional support. These people advised me that I should not feel like I am bragging when I am asked to talk about my accomplishments; I have worked hard to get to where I am and I should be proud of that. And guess what? I followed their advice. I am proud of my achievements. I am not ashamed or seek to minimise them out of fear of what others will think.

Last but not least, I acknowledge the feedback from my Ph.D. blog (a journey through academia and fashion), which has attracted hundreds of people who seek my advice on acquiring a Ph.D. degree. It means the world to receive so many encouraging messages from this community, cheering me on for the final big delivery of my doctoral thesis.

É maravilhoso ver os meus alunos saírem do museu com um sorriso no rosto.

It's wonderful to have my students leaving the museum with a smile on their faces.

– 29th March, 2019 –
A teacher from one of the schools that took part in the testing of 'Memories of Carvalhal's Palace'

Table of Contents

ABSTRACT

While museums are often designed to engage and interest a wide variety of audiences, teenagers are a neglected segment. This Ph.D. research in Digital Media explores how digital technologies can facilitate natural history museums in creating immersive museum experiences for teenagers (15–19 years old), through digital storytelling and gamification frameworks. This contribution is a set of guidelines that aids in designing enjoyable interactive experiences inside these museums for this target audience. For this research thesis, a total of 382 teenagers have been involved: 211 through co-design sessions (by which 130 of these took part in a focus group), and 171 in user testing. This work also involved 3 museums, 12 curators, and 17 master students as sources of information who took part in different research studies. Through qualitative analysis, the preliminary findings of this research suggest that teenagers value gamification and storytelling elements when thinking about enjoyable museum tours, while curators value story-based narratives as the most prominent method to provide enjoyable museum experience for teens. Based on the findings identified, and assisted by a team from the Interactive Technologies Institute (ITI/LARSyS), two different interactive mobile experiences targeted at teenagers were developed for the Natural History Museum of Funchal, Portugal: a story-based approach (*Turning Point*), and a game-based one (*Haunted Encounters*). These experiences were studied in depth with teenagers to understand how and why digital storytelling and game approaches might enhance the user experience of teenage visitors in a natural history museum. A classification for teenage visitors' experiences emerged from this last study, which is relevant for museum curators, designers and researchers in the fields of 'Museums', 'Human-Computer Interaction', and 'Interaction Design and Children'.

The contributions of this doctoral thesis can be summarized as: (i) one *framework* to co-design mobile museum experiences and enable teen participation; (ii) twenty-four *requirements* to design mobile museum experiences for teenagers; (iii) two mobile *apps* – story-based and game-based; (iv) six classifications of teenagers' *behavioural dynamics* in museums; and (v) twenty *guidelines* for the design and deployment of game-based and story-based strategies in museums targeted at teenagers.

Keywords: museums, natural history, teenagers, visitors, user experience, storytelling, gamification, co-design, museum experience designers

RESUMO

Embora os museus geralmente sejam projetados para envolver e interessar uma ampla variedade de públicos, os adolescentes são tipicamente um público negligenciado. Esta investigação doutoral em Media Digitais explora como as tecnologias digitais podem facilitar museus de história natural na criação de experiências imersivas destinadas a adolescentes (entre os 15 e os 19 anos) por meio de estruturas de narrativas digitais e de gamificação. Esta contribuição caracteriza-se como um conjunto de diretrizes que ajudará na conceção de experiências interativas agradáveis dentro deste tipo de museus para este público-alvo. Para esta investigação foram envolvidos 382 adolescentes: 211 por meio de sessões de *co-design* (nos quais 130 participaram num *focus group*) e 171 em testes de utilizador. Este trabalho também envolveu 3 museus, 12 curadores e 17 estudantes de mestrado como fontes de informação que participaram em diferentes estudos conduzidos. Por meio de uma análise qualitativa, os resultados preliminares desta pesquisa sugeriram que os adolescentes valorizam elementos de jogos e de narrativas quando pensam em visitas museológicas agradáveis, enquanto os curadores de museus valorizam as narrativas como o método mais importante para proporcionar uma experiência museológica agradável para este público. Com base nestes resultados, e assistida por uma equipa de investigadores do Interactive Technologie Institute, (ITI/LARSyS) desenvolvi duas diferentes experiências interativas móveis direcionadas aos adolescentes que visitam o Museu de História Natural do Funchal, Portugal: uma abordagem baseada numa história – Ponto de Viragem (*Turning Point*) e outra num jogo – Encontros Assombrados (*Haunted Encounters*). Estas experiências foram estudadas em profundidade com o público-alvo para entender como e por que narrativas digitais e elementos de jogos podem melhorar a experiência do adolescente num museu de história natural. Uma classificação da experiência destes visitantes emergiu desta última análise que é de interesse para curadores, *designers* e investigadores nas áreas de "Museus", "Interação Humano-Computador" e "Design de Interação e Crianças".

As contribuições desta tese de doutoramento podem ser resumidas em: (i) uma *framework* para *co-design* de experiências móveis para museus que permite a participação de adolescentes; (ii) vinte e quatro *requisitos* para desenhar experiências móveis em museus para adolescentes; (iii) duas aplicações móveis (baseadas numa história e num jogo); (iv) seis classificações da *dinâmica comportamental* de adolescentes em museus; e (v) vinte *diretrizes*

para o desenho e implementação de estratégias baseadas em jogos e histórias em museus, focadas em adolescentes.

Palavras-chaves: museus, história natural, adolescentes, visitantes, experiência de utilizador, narrativas, gamificação, desenho participativo, designers de experiências museológicas

Chapter #1
INTRODUCTION

This chapter comprises the motivation of the doctoral thesis in Digital Media, which can be phrased as: enhancing the museum experience of teenagers (15-19 years old) in natural history museums through gamification and storytelling frameworks. The description of the main contribution follows this motivation in the form of a set of guidelines, the research questions, the methodology addressed, the structure of this document, and scientific publications made.

1.1. MOTIVATION

Museums are described as places that materialize and visualize knowledge (Fyfe, 2006), at least for museums which have a physical space. Their goals are to collect, preserve and share that knowledge with the public. Museums are slowly but surely moving away from being collections of exhibits, to become centres where people can engage and empower their knowledge by discovering and challenging themselves (J. H. Falk & Dierking, 2000; Hawkey, 2004); visitors are turning from passive to active participants (Mancini & Carreras, 2010; Simon, 2010). Storytelling has been known to be an effective way to convey ideas and beliefs; museums not only tell us stories but also build those stories through the meaning-making process in which the visitors engage (Kelly, 2007). This fact allows museums' audience to indulge in narratives that aid the construction of meaningful memories as well as providing the fulfilment of a complete experience. Although the museums' spatially constructed narrative might be logically and consistently presented, not all visitors choose to follow, learn and engage with it (Stenglin, 2004). Though, there are absolutely cases where the visitor's mental model discords with the design of the exhibition that they are interacting with (D. Norman, 2013), changing the focus from experience onto the design itself, interrupting the flow (Csikszentmihalyi, 1998) which eventually leads to frustration and poor user experiences. Therefore, learners might fail to elaborately appreciate the exhibits due to its abundance of precious information and time constraints which may ultimately lead to information overload (Bitgood, 2009); or due to the lack of interest of visitors in the interpretation of the exhibit (Rhee & Choi, 2015).

Museums have different ways to involve the visitor, such as wall labels, audio guides, guided tours, and brochures, but these forms of communication are inherently limited. Wall labels and brochures might be very well designed, but they are static, do not afford any digital interaction. The audio guides as we know might contain exciting stories, but they are delivered in a static way where users are not able to dynamically request more information. Human led guided tours have a personal touch where visitors can have personalised questions answered, although they are limited to the specific knowledge of the guide. Aware of this fact, museums today are engaging with new and interactive technologies, challenging the old paradigms of audio and human guides. Mobile applications can engage visitors with a memorable approach (Bailey-Ross et al., 2016) and require minimal changes to an exhibition space. Mobile applications present many options that can be tailored individually to suit particular exhibits or

the visitors' current identity-related visit motivations. Furthermore, without some degree of digital interactivity, it is challenging for a museum to remain exciting and relevant to a young tech-savvy audience. With mobile guides, we have access to multimedia content in several formats. This fact allows museums to present visitors with many options to engage with the collections. It also allows visitors to explore the museum exhibits beyond basic facts, in a much broader way. Regarding exploration options, mobile guides offer visitors the structured approach of an organized tour, or they can follow a route by themselves. With the BYOD (bring your own device) approach (Song, 2014), mobile guides, to be downloaded into visitors' devices, can provide them with flexibility. Besides, games can benefit museums by promoting positive attitudes about museum spaces, as well as creating more joyful destinations in order to promote meaningful informal learning combined with entertainment (Edwards & Schaller, 2007). Implementing technology inside a space, promotes positive experiences for young visitors, which helps museums achieving greater visitation rates. In recent decades, many game-based museum programs have been designed for different media platforms and visitor types (Pierroux et al., 2007). Those games are frequently entailed with the goal of using mobile devices to guide families' explorations through mystery and treasure hunt solving (Cabrera et al., 2005; Dini et al., 2007) or event tasks to scaffold student's learning through school and museum contexts (Bakken & Pierroux, 2015; Charitonos et al., 2012; Pierroux et al., 2011). Some general goals for museum games encompass increasing museum's brand awareness; encourage new visitors to come; engaging visitors with the museum exhibits; familiarize visitors with the institution and exhibits, and changing visitor's behaviour in some way (Birchall et al., 2012).

The model of visitor experience that Falk proposed (J. H. Falk, 2009) takes into account that a visit to a museum develops long-term memories and meaning, predicting that different entering motivations result in different existing understandings. Also, the visitor notices that their museum visitor experience was less than satisfying if expectations are not met. Falk (2009) argues that museums should segment their audiences since each audience group, especially teenagers, is different regarding motivations, beliefs, and what to expect from a cultural heritage space (Napoli & Ewing, 2000). A study conducted by Falk and Dierking (1997) with three different age groups, about their memories regarding museums tours, revealed that memory seems to strongly hold together museum experiences. The study included eight years old recalling memories about museums trips of one to two years earlier; thirteen years old recalling memories about trips they had taken six to seven years before; and, young adults about trips they had taken anywhere from twelve to twenty years earlier. Nearly 100%

of the participants were able to describe details from their experience. This study did not encounter any difference across those three age groups concerning the strength or depth of the memories. Although this museum visitor experience model does not let us predict with certainty what every visitor will do and remember all of the time, it enables us to describe and predict the underlying trajectory of a significant percentage of museum visitors' experience. Despite the details of what the visitor remembers will vary, the basic form and structure of their memories are likely to be predictable. The key to understanding what is remembered depends on the perceptual filters that every visitor brings to museums. These filters create the lens by which memory is formed and recalled. Depending on the visitor's current identity-related motivations, the same individual can engage with the same exhibitions in fundamentally different ways (as an *Explorer, Facilitator, Experience Seeker, Professional/Hobbyist, and Recharger*). After the tour, the visitor uses their visit experience to improve and change their sense of identity and thoughts of the museum along with, in a small but significant way, how society understands this and other museums (J. H. Falk, 2009).

Museums tours are seen as social events because museums are mostly visited in school field trips, tourism trips, and even family trips. Hence, Human-Computer Interaction (HCI) research in museums is a vast field (Eva Hornecker & Ciolfi, 2019). However, not all museums are designed to offer an exciting experience to suit all demographics. We often verify solutions for children, adults, and even families. Still, the teenage audience is left somewhere in the middle between children and adults in the HCI research. This user group has a valuable set of ideas; additionally, and as found by Fitton et al. (2013), they are in a better position of combining both child and adult perspectives.

According to Falk (2009), the so-called 'one size fits all' principle does not apply to visitor experiences. Notably, teenagers seem to be a difficult audience to engage, and at the same time, a neglected typology of visitors for cultural heritage sites. 'Generation Z' (13-18 years old) is mainly seen as entirely different from previous generations, particularly regarding their beliefs and behaviours (Wikia, 2013). This generation is identified as an audience group that is often excluded from a museum's curatorial strategies (Tzibazi, 2013) and as a consequence they appear to be generally disinterested in what museums might offer.

The target audiences are the final users; hence, it is crucial to study their interests and desires, having them as 'sources of innovation' (Holmquist, 2004) and 'design partners' (Druin, 1999), in order to deploy a high quality and enjoyable product. To date, museums have reached out to specific audiences in the form of surveys and questionnaires. In order to obtain relevant information and support the design of exhibitions and interpretive experiences, this

process has mostly followed a top-down approach (Simon, 2010). In fact, only a few examples demonstrate how museums can actively involve communities in an ideation process that is aimed at improving audience engagement. The Glasgow Open Museum Experiment is often presented as a relevant example. Set in the 1990's, this experiment, amongst others, involved local and mostly marginalized groups in the organization and curation of the museum's exhibitions (Simon, 2010). Reported by Simon, an impact assessment of Glasgow's Open Museum experiment, conducted in 2002, demonstrated that this project propelled two important contributions. Firstly, the project created 'new opportunities for learning and growth' amongst excluded audiences. Secondly, it changed the negative perception of museums amongst marginalized groups.

Cultural Heritage Professionals (CHPs) are responsible for shaping experiences within cultural heritage spaces, and should also be involved in the ideation of interactive tools as active players in the development of the technology design process (Ciolfi & Petrelli, 2016). It is crucial to involve CHPs in the design process to attract teenagers, given they are the adults of tomorrow and a future museum audience, which is currently neglected by curatorial strategies. Understanding how people interact with cutting-edge technological solutions is a crucial aspect of HCI. Hence, it is crucial for the researchers in the HCI field to pay attention to the people (curators, staff, volunteers) who are in charge of transmitting the ideology of museums as places of encounters of technology (Ciolfi & Petrelli, 2015). Since CHPs spend a considerable amount of time in the museum, they develop detailed knowledge along with their perspective of the exhibits, and this eventually gets transferred as experiences to the audience, who become a fertile area for HCI investigations.

During the last decades, museums have been witnessing a decrease in visitors. The Louvre Museum in Paris has announced that its visitor figures have fallen by 15 percent in 2016, US Art museum attendance dipped 5 percent from 2002 to 2012, according to the US National Endowment for the Arts (Cannell, 2017). Museum visitors of 75 and older were the only age group to increase over that period (Cannell, 2015). A BBC analysis on the National Gallery and Tate report a loss of 20% of their British audience in a five-year period up to 2014 (Jones, 2017). At the same time, gamification and playful interaction (Deterding et al., 2013) afforded by the widespread of mobile personal devices (in museum settings) offers opportunities to attract young visitors (Beale, 2011) enabling a closer relationship with a museum's stories and exhibits. Blanchard and Cheska (1986) state that play is widely perceived as an accepted form of learning. Several scholars also agree that most of the popular games are

'untapped educational resources' (Futurelab, 2009) which might provide 'a glimpse of how we might create new and more powerful ways to learn' (Shaffer et al., 2005).

Recently, several studies (Barbieri et al., 2017; J. Falk, 2016; J. H. Falk et al., 1998; Segall & Trofanenko, 2016) have questioned the museum's mission to educate, versus the visitors' desire for entertainment. In fact, while museum professionals focus more on educational values, audiences appreciate museums for their entertainment aspects. Traditionally, museums have provided the public with access to cultural, scientific, and historical exhibits as well as to informed commentary and research. However, the museum experience should be more than knowledge transfer (Mann et al., 2013). Therefore, museums are increasingly adopting technologies to support more engaged learning. Should the focus persist on educational value above entertainment, even though studies suggest that visitors are secretly seeking the opposite? At what point does the vision of the cultural heritage place overtake the preferences of the audience? The dichotomy of education versus entertainment is also questionable: the edutainment (Klopfer et al., 2009). This concept can act as an excellent gateway to education, in particular with today's teenage audiences and their fast-paced information consumption and preference for gamification strategies (Mann et al., 2013), as it is the process of entertaining people at the same time they are thought something. Whatever the primary goal of the institution, a two-way strategy that balances entertainment with education could help museums in strengthening their mission as well as fulfilling audience needs. Games and narrative elements are proven to improve engagement, motivation and learning within edutainment environments (Jemmali et al., 2018).

1.2. CONTRIBUTION AND RESEARCH QUESTIONS

The main contribution of this doctoral research is a set of findings and guidelines that will aid in the designing of interactive experiences inside natural history museums encompassing digital storytelling and gamification frameworks for the teenage audience (15-19 years old). I position 'gamification' as the use of game elements which entice engagement on the user that is used for other purposes than an entertainment game such as in gamified museum experiences (challenges, treasure-hunts, clues, puzzles and quizzes).

Through this research, I intend to help natural history museums come alive through technology as well as by providing more engaging experiences for teens to create awareness of the museum message.

With the present motivation and problem statement, the following thesis will be addressed through this Ph.D.:

Guidelines on utilising digital storytelling and gamification apps to enhance the museum experience of teenagers and create awareness of the museum message.

To address this broad topic, I broke down the research into the following research questions[1]:

1. What type of experiences would teenagers like to have in a museum?
2. Why do teenagers choose technologically mediated interactive experiences in museums?
3. Is a gamified experience important for a museum tour?
4. Is a gamified experience adequate for a museum?
5. How can we gamify the current stories and knowledge in museums?
6. How does a digital storytelling and game-based approach enhance the user experience of teenage visitors in a museum?

The next section, '*Methodology'*, describes how these questions were answered using a set of participatory methods, tasks, and studies carried out through the Ph.D. research project

[1] Although the research questions are broader in scope, I have studied a specific domain: school visits from students of informatics, multimedia and social sciences classes at a museum of natural history. I intended to approach not only teenagers from one single background but also teenagers from slightly different contexts, to gather general trends to enhance their engagement towards museum visits. These guidelines could be used as a starting point in the development of mobile museum experiences targeted at older teenagers.

in Digital Media. Almost all the studies were published in international conferences on Human-Computer Interaction.

1.3. METHODOLOGY

In order to answer the research questions above mentioned, my research was conducted by using a threefold approach[2] (Fig. 1).

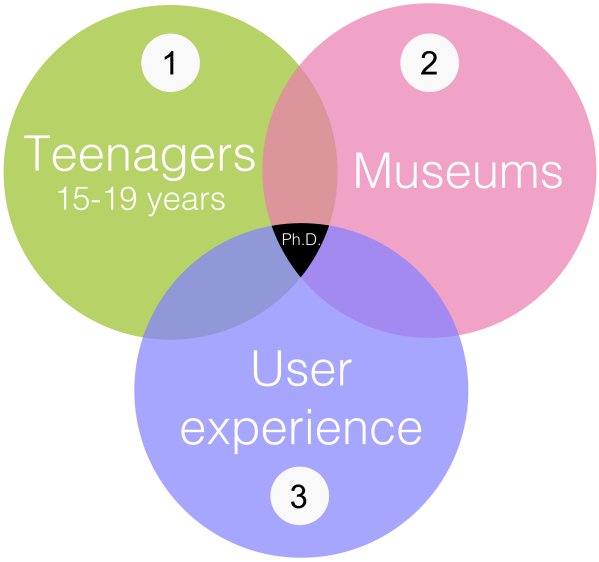


Figure 1. *Graphic of the methodology used for this doctoral thesis. Firstly, teenagers were studied. Secondly, museums were approached. And finally, based on the findings identified in those previous studies, the user experience design took place.*

Firstly, I studied the interests of teenagers regarding how/what they would improve in a museum tour in order to be more appealing for them. Secondly, I studied how museums and curators perceive teenagers as an audience group. The teenagers enlightened me on the mechanics of the experiences which would be appealing for them, while museums' professionals guided me through which kind of content and messages they would like to convey. Below are the topics of the studies conducted with both teenagers and museums divided into three segments in a total of 7 studies carried:

1) Understanding teens and their museum experiences. In this first segment, I placed teenagers as informants, and developers of museum experiences. Following Druin's framework (2002), 130 teenagers acted as informants during a focus group to understand their thoughts and engagement towards engaging museum experiences (study #1). And finally, 13

[2] The confidentiality of participants was maintained in the following manner: the data and consent form was kept separate. The consent forms were stored in a locked location on ITI/LARSyS property and will not be disclosed to third parties. By participating, participants understood and agreed that I might use the data and information gathered during the study. To protect their privacy, they were assigned a code number, and the collected data was recorded by this code, NOT their name. Their participation was voluntary. They were free to stop their participation at any point. Refusal to participate or withdrawal of their consent or discontinued participation in the study did not result in any penalty or loss of benefits or rights to which they might otherwise be entitled.

teenagers worked as developers in the creation of mobile experiences for museums assisted by the HP Reveal Studio, an Augmented Reality tool (study #2). My main goal was to gather feedback and insights on how they perceive the museums' offerings as well as to understand how they think interactive technologies could enhance their overall experiences at a museum.

2) Framework for co-designing museum mobile experiences. In this second segment, I describe a study with 155 teenagers positioned as designers of technologies through a framework that is intended to enable teen participation in the design of mobile interpretive exhibitions through user-driven innovation. The data was analysed thematically according to three main topics: (i) patterns that experience designers and curators could access to understand which design features an enjoyable museum experience for teenagers should have (study #3); (ii) highlighting which kind of narratives and mechanics the mobile museum experience should follow in order to attract teenagers' audiences (study #4). And finally, (iii) the teenagers' impression on the co-design process itself, and the proposed framework (study #5).

3) Understanding how museum professionals see teenagers as visitors. In the third segment, I aimed to get insights from museums' Cultural Heritage Professionals (CHPs) about how they perceive teenagers in museums tours. For this set of research studies, I focused on doing a comparative study between the views of 43 teenagers and 17 curatorship students (students taking a master in Cultural Management) on enjoyable museum tours targeted at teens, and for this, I used thematic analysis (study #6). To complement this topic, I also conducted co-design sessions with a group of 12 CHPs which ended up in a series of tangible digital interactive prototypes developed and targeted at teenagers that were tested by both 12 CHPs and 12 teenagers (study #7).

Then, based on the findings from this set of research studies, I distilled a series of requirements an enjoyable museum experience could adopt to catch teenagers' attention and promote awareness regarding the museum message inside a natural history museum. Finally, based on the requirements identified two interactive mobile experiences targeted at teenagers were developed for the Natural History Museum of Funchal: a story-based approach (*Turning Point*), and a game-based approach (*Haunted Encounters*). I would like to clarify that the ideation, and production of the digital interactive exhibits, as well as support to conduct the research studies regarding these artefacts, were made in collaboration with a team of artists and researchers, part of the Sense&Tell[3] research group at ITI/LARyS[4]. The design, overall

[3] https://senseandtell.m-iti.org/
[4] https://iti.larsys.pt/larsys/

management and analysis of the studies, were done my myself. Both approaches were tested with a sample of 159 teenagers in order to check if the identified requirements work when applied to a real-life scenario. In addition, and as a concluding remark and contribution of this thesis, I list a set of guidelines that museum experience designers and curators could utilise when designing mobile museum experiences targeted at teenagers 15-19 years old.

1.4. THESIS STRUCTURE

This thesis is divided into seven chapters and an appendix.

Chapter #1, '*Introduction*', covers the motivation of the work, providing the contribution and research questions accompanied by the methodology used to guide the user throughout the thesis. At the end, the chapter lists the publications made throughout this four-year doctoral journey.

Chapter #2, '*State of the art'*, provides the reader with a clear focus on the key aspects related to this thesis. It starts by offering a general description of the fundamental concepts addressed: storytelling, games, user experience, usability, and user-centred design. Then, it relates all the state of the art used for the studies conducted, addressing the following topics: (i) the museum experience, (ii) digital interactions in museums, and (iii) teenagers as the target audience.

Chapter #3, '*Methodology'*, starts by describing the museums that collaborated in this work and then the studies conducted with teenagers (five studies) and museum professionals (two studies) into three subsections: (i) '*Understanding teens and their museum experiences*', (ii) '*Framework for co-designing mobile museum experiences*', and (iii) '*Understanding how museum professionals see teenagers as visitors*'. Each study is accompanied by its aim, methodology applied (sample, procedure, and analysis), results, and main takeaways. Finally, each subsection closes with a concluding section. The chapter finishes with an overall discussion as well as the main research findings, and lists the requirements gathered from the previous studies in order to design an enjoyable museum experience for teenagers.

Chapter #4, '*User experience design'* embeds some of these requirements into two mobile experiences, describing the entire procedure of accepting and dismissing requirements, as well as the entire process of conceptualizing, designing, and developing the prototypes.

Chapter #5, '*Validation: Evaluation of the user experience'*, describes the research design for the evaluation of the two mobile applications and the consequent validation of the requirements applied to the two mobile applications. This study encompassed 159 teenagers and included two different analyses: a qualitative one, characterizing teenagers as different types of visitors when using different mobile engagement strategies; and a quantitative one, understanding which engagement strategies in the prototypes work better in terms of enhancing teenagers' overall museum experience and why.

Chapter #6, '*Guidelines for design*', reflects the main contribution of this doctoral thesis: a set of guidelines for the design of mobile experiences in natural history museums targeted at teenagers aged 15-19. It integrates a reflection on the requirements implemented on the prototypes and what we can learn after their validation through the evaluation by teenagers.

Chapter #7, '*Conclusions & future work*', addresses the main limitations of this work and answers the research questions previously mentioned in Chapter #1. It also elaborates on the future research lines for this topic.

Finally, the '*Appendix*' includes all the questionnaires and informed consents used in each of the studies carried, as well as the tutorials and other material related to the design of the two mobile apps.

1.5. PUBLICATIONS

The majority of the work presented throughout this thesis was the result of publications in several international conferences in the field of Human-Computer Interaction. In this section, I list the practical work published along with which chapters they can be found.

Vanessa Cesário, Daniela Petrelli, and Valentina Nisi. 2020. Teenage Visitor Experience: Classification of Behavioral Dynamics in Museums. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (CHI '20)
https://doi.org/10.1145/3313831.3376334

- *Chapter #5 'Evaluation of the User Experience' – Approach #1: Types of teenage visitors*

Valentina Nisi**, Vanessa Cesário**, Nuno Nunes. 2019. Augmented Reality Museum's Gaming for Digital Natives: Haunted Encounters in the Carvalhal's Palace. In *Proceedings of the Entertainment Computing and Serious Games* (ICEC-JCSG '19)
https://doi.org/10.1007/978-3-030-34644-7_3

- *Chapter #4 'User experience design' – Game-based: Haunted Encounters*

Vanessa Cesário, António Coelho, and Valentina Nisi. 2019. 'This Is Nice but That Is Childish': Teenagers Evaluate Museum-Based Digital Experiences Developed by Cultural Heritage Professionals. In *Proceedings of the 2019 CHI Conference Extended Abstracts on Human Factors in Computing Systems, Fun and Games and Gamification* (CHIPLAY EA '19)
https://doi.org/10.1145/3341215.3354643

- *Chapter #3 'Methodology' – Study #7: Cultural Heritage Professionals develop museum-based digital experiences targeted at teenagers*

Vanessa Cesário, Rui Trindade, Sandra Olim, and Valentina Nisi. 2019. Memories of Carvalhal's Palace: Haunted Encounters, a Museum Experience to Engage Teenagers. In *Proceedings of the 17th International Conference on Human-Computer Interaction* (INTERACT '19)
https://doi.org/10.1007/978-3-030-29390-1_36

- *Chapter #4 'User experience design' – Game-based: Haunted Encounters*

Vanessa Cesário, António Coelho, and Valentina Nisi. 2019. Word Association: Engagement of Teenagers in a Co-design Process. In *Proceedings of the 17th International Conference on Human-Computer Interaction* (INTERACT '19)
https://doi.org/10.1007/978-3-030-29390-1_65

- *Chapter #3 'Methodology' – Study #5: Engagement of teenagers*

Vanessa Cesário. 2019. Guidelines for Combining Storytelling and Gamification: Which Features Would Teenagers Desire to Have a More Enjoyable Museum Experience? In *Proceedings of the 2019 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (CHI EA '19)
https://doi.org/10.1145/3290607.3308462

- *Chapter #4 'User experience design' – The mobile apps*

Vanessa Cesário, António Coelho, and Valentina Nisi. 2018. Co-Designing Gaming Experiences for Museums with Teenagers. In *Proceedings of the 07th EAI International Conference: ArtsIT, Interactivity and Game Creation* (ArtsIT '18)
https://link.springer.com/chapter/10.1007/978-3-030-06134-0_5

- *Chapter #3 'Methodology' – Study #2: Development of gaming experiences through an Augmented Reality tool*

Vanessa Cesário, António Coelho, and Valentina Nisi. 2018. Cultural Heritage Professionals Developing Digital Experiences Targeted at Teenagers in Museum Settings: Lessons Learned. In *Proceedings of the 32nd British Human-Computer Interaction Conference* (BHCI '18)
http://dx.doi.org/10.14236/ewic/HCI2018.58

- *Chapter #3 'Methodology' – Study #7: Cultural Heritage Professionals develop museum-based digital experiences targeted at teenagers*

Vanessa Cesário, António Coelho, and Valentina Nisi. 2018. Design Patterns to Enhance Teens' Museum Experiences. In *Proceedings of the 32nd British Human-Computer Interaction Conference* (BHCI '18)
http://dx.doi.org/10.14236/ewic/HCI2018.160

- *Chapter #3 'Methodology' – Study #3: Design patterns*

Vanessa Cesário. 2018. Analysing Texts and Drawings: The Teenage Perspective on Enjoyable Museum Experiences. In *Proceedings of the 32nd British Human-Computer Interaction Conference* (BHCI '18)
http://dx.doi.org/10.14236/ewic/HCI2018.216

- *Chapter #3 'Methodology' – Study #3: Design patterns*

Vanessa Cesário, António Coelho, and Valentina Nisi. 2017. Teenagers as Experience Seekers Regarding Interactive Museums Tours. In *Proceedings of the 1st International Conference on Design & Digital Communication* (DIGICOM '17)
ISBN: 978-989-99861-5-2

- *Chapter #3 'Methodology' – Study #1: Focus groups*

Vanessa Cesário, António Coelho, and Valentina Nisi. 2017. An unlikely seamless combination – future curators designing museum experiences towards the desires of actual teenagers. In *Proceedings of the 1st International Conference on Design & Digital Communication* (DIGICOM '17)
ISBN: 978-989-99861-5-2

- *Chapter #3 'Methodology' – Study #6: Curatorship students design museum experiences towards teenagers*

Vanessa Cesário, Marko Radeta, Sónia Matos, and Valentina Nisi. 2017. Designing Interactive Technologies for Interpretive Exhibitions: Enabling Teen Participation through User-Driven Innovation. In *Proceedings of the 16th International Conference on Human-Computer Interaction* (INTERACT '17)
https://doi.org/10.1007/978-3-319-67744-6_16

- *Chapter #3 'Methodology' – The framework*

OTHER PUBLICATIONS

In this section, I list all the other scientific contributions done throughout this 4-year Ph.D. journey. These publications are the result of the attendance in doctoral consortiums, courses done during the first year of this doctoral program, and studies on the creation and development of the mobile app '*Ocean Game'* that was intended for children visitors of the Natural History Museum of Funchal.

Vanessa Cesário, António Coelho, and Valentina Nisi. 2017. Enhancing Museums' Experiences Through Games And Stories For Young Audiences. In *Proceedings of the 10th International Conference on Interactive Digital Storytelling* (ICIDS '17)
https://doi.org/10.1007/978-3-319-71027-3_41

- *Doctoral consortium*

Marko Radeta, **Vanessa Cesário**, Sónia Matos and Valentina Nisi. 2017. Gaming Versus Storytelling: Understanding Children's Interactive Experiences in a Museum Setting. In *Proceedings of the 10th International Conference on Interactive Digital Storytelling* (ICIDS '17)
https://doi.org/10.1007/978-3-319-71027-3_14

- *'Ocean Game' project*

Vanessa Cesário, Marko Radeta, Sónia Matos and Valentina Nisi. 2017. The Ocean Game: Assessing Children's Engagement and Learning in a Museum Setting Using a Treasure-Hunt Game. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems, Fun and Games and Gamification* (CHIPLAY EA '17)
https://doi.org/10.1145/3130859.3131435

- *'Ocean Game' project*

Vanessa Cesário, Marko Radeta, António Coelho, and Valentina Nisi. 2017. Shifting from the Children to the Teens' Usability: Adapting a Gamified Experience of a Museum Tour. In *Proceedings of the The 16th International Conference on Human-Computer Interaction* (INTERACT '17)
https://doi.org/10.1007/978-3-319-68059-0_52

- *'Ocean Game' project*

Vanessa Cesário, António Coelho, and Valentina Nisi. 2017. Audio Guides and Human Tour Guides: Measuring Children's Engagement & Learning at a Museum Setting. In *Proceedings of the The 12th Biannual Conference of the Italian SIGCHI Chapter* (CHITALY '17)
http://ceur-ws.org/Vol-1910/paper0208.pdf

- *'Research Methods' course*

Filipa Nóbrega, Eduardo Gomes, Harry Vasanth, Henrique Ferreira, **Vanessa Cesário**, Paulino Caetano, Paulo Mendez, Jéssica De Pontes, and Gian Spicci. 2017. Designing Multi-Gateway Interactions In A Multi-Player Strategy Game. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (CHI EA '17), 226–229.
https://doi.org/10.1145/3027063.3048411

- *'Game Design' course*

Vanessa Cesário, Valentina Nisi, and António Coelho. 2017. ClueKing: Allowing Parents to Customize an Informal Learning Environment for Children. In *6th Conference on Serious Games, Interaction and Simulation | Springer*, Carlos Vaz de Carvalho, Paula Escudeiro and António Coelho (eds.). ICST Institute for Computer Sciences, Social Informatics and Telecommunications Engineering 2017. (SGAMES '16)
https://doi.org/10.1007/978-3-319-51055-2_4

- *'Media Laboratory' course*

Vanessa Cesário, Joel Rodrigues, Helen Li, Iris Wu, and Valentina Nisi. 2016. Crescendo: Routine Learning App for Children with Autism Spectrum Disorders. In *Proceedings of the The 15th International Conference on Interaction Design and Children* (IDC '16), 571–576. https://doi.org/10.1145/2930674.2935997

- *'Interaction Design' course*

Vanessa Cesário, Paulo Freitas, Diana Pimentel, and Valentina Nisi. 2016. Children's Books: Paper VS Digital, What Do They Prefer? In *Proceedings of the The 15th International Conference on Interaction Design and Children* (IDC '16), 625–630. https://doi.org/10.1145/2930674.2936004

- *'History and Trends of Digital Media' course*

Chapter #2
STATE OF THE ART

This chapter describes the concepts and the State of the Art addressed in this thesis, namely: (i) Fundamental concepts; (ii) The museum experience, (iii) Digital interaction in museums; and finally (iv) Teenagers as target audience.

2.1. FUNDAMENTAL CONCEPTS

This section describes the fundamental concepts that are addressed in the thesis: (i) storytelling, (ii) games, (iii) interaction design, (iv) usability, and (v) user-centred design.

STORYTELLING AND LOCATION-AWARE MOBILE NARRATIVES

Stories are the foundation of human communication. Storytelling is, first of all, an art of entertainment even when first relayed in campfires. The process of storytelling always involves the story itself, a narrator, a medium, and an audience. Stories are particularly important not only for adults but children as well. Stories help children to create their identity, presenting a gateway to the minds of others, offering them a model and a way to project, handle and solve their existing conflicts. Thus, stories help children to clarify their emotions, anxieties, fears, and aspirations (Cooper, 2007; Engel, 2005; Paley, 2005; Wright et al., 2008). Storytelling is also considered an essential dimension of cognitive and affective development (Bruner & Haste, 2010; Eagle, 2012), providing opportunities for social interaction (Speaker et al., 2004) and innovative thinking: it exercises our emotions, opens new windows to the imagination, it enlarges and enriches our life experience. Over the centuries, stories have always challenged new technologies and moved from oral, to print format, and then to the cinema, television, computer screens and now to smartphone and public screens.

Stories, whether fictional or inspired by real events are a mighty mean of communication. They can connect us to distant places and times, providing us with a cultural legacy to pass to future generations, with inspirational examples for our lives, and allowing us to remember memories and anecdotes (Nisi et al., 2006). Today, mobile, wireless and tag sensing technologies have enabled the development of new media formats and applications for creative expression and storytelling. Social media sites such as Foursquare, Facebook, Twitter, and Flickr enable us to rapidly create, manipulate and consume information about people, objects, places, and events in real time. Through these communication acts we contribute to a wide variety of stories (Nack & Waern, 2012). By co-locating places and stories, we can create a rich synergetic experience of place, a complimentary merging of narrative and environment (Nisi et al., 2004). Location-aware mobile narratives systems create a digital landscape which overlays the physical world, whereby every place can become a stage for a rich new experience (Reid et al., 2005). These systems when applied to cultural heritage spaces have significant potential, because such systems can allow communities in providing an open space in which

they can express, recall, and celebrate the history and culture of their neighbourhood, supporting the perception of it as a cultural place as opposed to simply a space (Nisi et al., 2006).

GAMES

As described by Rolling & Adams (2003), a game is "a form of interactive entertainment where players must overcome challenges, by taking actions that are governed by rules, in order to meet victory condition". In 1938, Johan Huizinga wrote *Homo Ludens* (Huizinga, 2016), a book where he recognized the game as something innate to humans and even animals, considering it a primary category of life, prior to culture. Huizinga (2016) states that a game "is a voluntary activity or occupation, exercised within certain specific limits of time and space, according to rules freely consented but absolutely mandatory, which has an end in itself, accompanied by a feeling of tension and joy and an awareness of being different from 'everyday life'."

When the topic of game and human evolution is approached, it is quintessential to touch on three of its distinctive aspects: *ludus* (latin word for 'play'), narrative, and aesthetics. The *ludus* concerns not only the games but the fun aspects of learning along with our ability to adapt. The human brain releases endorphins when we solve a given problem, supporting that we are made to solve problems, and this links pleasure to game mechanics. The game mechanics bring problems for the human being to solve, and the human has a great desire for problem-solving. Narrative is a fundamental device for human beings, describes what we are, and our history. Therefore, the narrative is intrinsic to human beings, and it is the basis of the culture of a people, being intrinsic to all cultures (Huizinga, 2016). Aesthetics are an essential part of our social structure. Since the Palaeolithic era that aesthetics are part of our human nature, and it is related to the game component, as it is related to the way a game looks, sounds and it is presented to the player (Huizinga, 2016). These three game components are intrinsic to humans.

In the rest of this section, I describe five concepts related to games. Firstly, '*Digital games*' – where a game's interactive element is a significant part of our everyday life. Secondly, '*Serious games*' – which are games used for other purposes besides entertainment. Thirdly, '*Pervasive games*' – which brings games into new contexts, situations, and spaces. Fourthly, '*Gamification*' – which uses elements of games for other purposes than their regular expected use as part of an entertainment game. And finally, '*Collection*' – the act of collecting a variety of things, a game element widely used.

DIGITAL GAMES

'Digital games' are defined by Rollings & Adams in the book *On Game Design*, as "a game is a form of interactive entertainment where players must overcome challenges, by taking actions that are governed by rules, in order to meet a victory condition" (Rollings & Adams, 2003). This definition leads us to consider that a game's interactive element is a significant part of our everyday life. We, as players have to overcome challenges, resolving problems which are created by those challenges. Each game has a set of rules, the game mechanics, that define the actions the player can use to overcome the challenges. Having specific goals is important to improve the player's experience and drive her/him to win the game. Jessy Schell (2008) formulates a definition of games based on four elements, the elemental tetrad: mechanics, narrative, technology, and aesthetics. In mechanics (a predominant element) we have the procedures and rules of a game, which is what distinguishes it from linear experiences such as books and movies. The game narrative (also a predominant element) is the sequence of events which unfolds in a game. The technology (the most hidden part) is where some aesthetics takes place, where the game mechanics occur and where the narrative is told. The aesthetics (the most visible part) defines how the game is perceived, including all the images, sounds, smells, flavours, that drive the player's emotional connection to the game. All these elements together make the game work as an experience generator. The classic theory in favour of the use of games in learning activities is that games induce an experience of 'flow' in which the gamer loses a sense of time and becomes lost in the activity (Csikszentmihalyi, 1998). Others argue that games increase children's sense of agency and power and interactivity (Ermi & Mäyrä, 2005). Other factors relevant to cognitive development include the power of interactivity and visual stimulation. Over the last few years, there has been considerable interest in the power of video games not just to entertain but to promote learning, health, social change, and art (Rigby & Ryan, 2011). Many believe that the deep source of this power is the ability of video games to attract and motivate players (Rigby & Ryan, 2011) together with a capacity to promote problem solving activities. MDA (Mechanics, Dynamics, and Aesthetics) is a formal approach to understanding games. One which attempts to bridge the gap between game design and development, game criticism, and technical game research. Designers/teams of developers create games that are consumed by players. They are purchased, used and eventually cast away like most other consumable goods. The difference between games and other entertainment products (such as books, music, movies, and plays) is that their consumption is relatively unpredictable (Hunicke et al., 2005). Mechanics describes the particular components of the

game, at the level of data representation and algorithms. Dynamics describes the run-time behaviour of the mechanics acting on player inputs and each other. Aesthetics describes the desirable emotional responses evoked in the player when she interacts with the game system (Hunicke et al., 2005).

SERIOUS GAMES

Games used for other purposes besides entertainment are known as 'Serious games' and have been used with success in several areas, such as in education and training, science and research, training and advertisement. 'Serious games' (Abt, 1987) date back several years (Halter, 2006) migrating from mainly military uses into education and business in the second half of the 20th century. Such digital, serious games can be defined as "any form of interactive computer-based game software for one or multiple players to be used on any platform and that has been developed with the intention to be more than entertainment" (Ritterfeld et al., 2009, p. 6). Examples of serious games are *MathBlaster* and *Re-Mission*. On education, *MathBlaster*[5] is a game from the 80s and its main objective is to shoot space garbage containing the result of a math equation that appears in the screen. This game promotes learning and mental calculation which can have a very positive effect on people. On health, we have *Re-Mission* [6] which are games created for children with cancer. The games engage young cancer patients through entertaining game play while impacting specific psychological and behavioural outcomes associated with successful cancer treatment. These games available at no charge to young people with cancer and their families, as well as oncology healthcare workers and institutions around the world.

Serious games provide a platform for active learning as the students cannot take a passive attitude. Instead, they are involved in activities promoting learning by doing rather than listening or reading. Furthermore, games provide immediate feedback to students at each challenge, thus being more efficient than regular assessment by tests and exams. Games also allow active discovery of the learning subjects and this process develops new kinds of comprehension. This approach also promotes a higher level of retention, which is of great importance to learning curricula. Magennis & Farrell (2005) reported that students who learn by doing have an average retention rate of 75% compared to an average retention rate of 5% for those who learn from lectures while other authors found a retention rate of 90% from

[5] http://www.mathblaster.com/
[6] http://www.re-mission.net/

simultaneously seeing, hearing, and doing, 80% from doing, 40% from seeing, and 20% from hearing (Binsubaih et al., 2009).

Pervasive Games

In parallel to the 'Serious games' movement, new game genres evolved that stretched the traditional limits of games, bringing games into new contexts, situations, and spaces (Deterding et al., 2011). Among these new types of games we enlist 'Pervasive games', games that have "one or more salient features that expand the contractual magic circle of play spatially, temporally, or socially" (Montola et al., 2009, p. 12). 'Pervasive games' intend to directly exploit the richness of the physical world as a means for play by complementing digital media with our everyday experience (Capra et al., 2005). The physical world is rich in information, supplying us at each moment with a constant stream of new images, sounds and also feelings. In 'pervasive games', sensors capture information about a player's context and current location. This information is used to deliver players a gaming experience that shifts according to where they are, what they are doing, and possibly, even how they are feeling (Capra et al., 2005). Examples of pervasive games are (i) location-based games that take gameplay into public space; (ii) Augmented Reality games that use digital devices to overlay game representations over the environment; (iii) persistent games that continually run to be entered and exited during the day; (iv) Alternate Reality games which "take the substance of everyday life and weave it into narratives that layer additional meaning, depth, and interaction upon the real world" (Montola et al., 2009, p. 37).

Gamification

Similar to 'Serious games', 'Gamification' (Fig. 2) uses elements of games for other purposes than their regular expected use as part of an entertainment game (Deterding et al., 2011). Just as there are training games, health games, or news games, there can be gameful design or gamification for training, for health, for news, and for other application areas (Deterding et al., 2011).

In gamification, we should consider the participant as a player, which is at the centre of the game, where the player must always feel in control (Kim, 2011). These are the first rules of gamification. Secondly, the player must continue to maintain the motivation to continue playing (Kim, 2011). Most strategies use PBL (points, badges, and leader boards). The points have an advantage because they influence the feedback, make a progress summary and keep score. The badges have a style that fits in every situation, they are also a sign of the importance

of the player, provide access to other levels allow to be collected, it is a status symbol. The leader boards give the competitors feedback; however, they must be used with caution, because if the difference is large relative to the level of other players, there is a risk of disappointment and demotivation. This PBL triad is not the magic solution. The elements of the game are not the game. Not all rewards are fun, and not all the fun is rewardable.

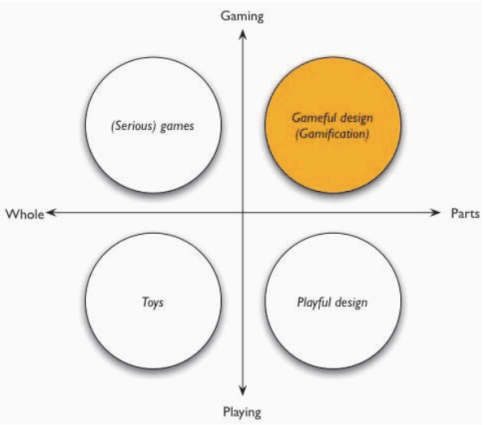


Figure 2. *'Gamification' between game and play, whole and parts, from Deterding et al, 2011.*

COLLECTION

From an early age, children are encouraged to collect a variety of things, from football cards or cartoon characters, animals, Legos, cars, etc. However, as a starting point, it is important to conceptualise what is meant by 'collecting'. Belk (1995) and Farina & Toledo (2006) define the act of collecting as the process of acquiring and possessing things in an active, selective and passionate way. Still, according to the previous authors, the fact that there is no universal theory for 'collecting' comes from the fact that there is no single motivation to 'collect', nor even a common meaning for the satisfaction obtained.

INTERACTION DESIGN

Nowadays, people are surrounded by a diversity of digital media that demands attention, and most often, interactions. Interactive media has become one of the primary methods of obtaining information. Concerning interaction design, Norman (2013) stated that "the focus is upon how people interact with technology. The goal is to enhance people's understanding of what can be done, what is happening, and what has just occurred. Interaction design draws upon principles of psychology, design, art, and emotion to ensure a positive, enjoyable experience." (D. Norman, 2013, p. 5). Preece et al. (2015) describes interaction design as an umbrella designation of academic disciplines and design practices. They define

that interaction design concerns "designing interactive products to support the way people communicate and interact in their every day and working lives." (Preece et al., 2015, p. 8).

Regarding human-computer interface and user interface design, Bill Buxton (2007) argues "this has always been about where the human and the computer meet." The goal of interaction design is to make communication and interaction between human and computer more comfortable to use and understand. Interactions become pleasant and smooth when users perceive the proposed user interface design. Although simplicity is a crucial feature of interface design, Donald Norman (2010) holds that what we need is not a 'simple design' but a 'good design' which manages 'complexity' successfully, because our society is overwhelmed by chaos. A well-designed interface should be ready to motivate users, boost ease of use and accessibility, enhance the accuracy and retention of information, and focus on the needs of its users (Watzman, 2003).

USABILITY

Measuring and evaluating the usability of interactive systems and interfaces is an ongoing challenge for teams that are concerned with improving the user experience (Finstad, 2010). The success of any software depends on several factors and usability is one of the most significant ones (Sauro, 2015). Numerous usability evaluation methods can be used to estimate the usability problems at the earlier stage of software design in order to overcome the severity level and withdraw the rework of design (Djamasbi & Wilson, 2017; Finstad, 2010; Lund, 2001; Sauro, 2015). It involves a persona engaging with the design and provides feedback on that design to a facilitator. The usability test allows identifying what works and what does not. By testing designs earlier, we can quickly identify potential problems with the interface before it becomes available out there for the target public (Dickerson, 2013) (Djamasbi & Wilson, 2017). Nowadays, usability is the core cause of the success of any technical product (Sauro, 2015), and this also is literally applied to games, which if it they are hard to use, will most possibly fail at the market level. Since the contemporary trend of museums is to empower their visitors, usability becomes a quintessential factor for the designers who tailor the content. Besides, principles and practices need to be further explored in order to emphasize interactivity and promote engagement.

USER-CENTRED DESIGN

User-centred design is an iterative design process in which designers focus on the users and their needs in each phase of the design via a variety of research

and design techniques, to create highly usable and accessible products for them. In the 1980s the user-centred design emerged and seemed to involve users in an iterative development life-cycle of technologies actively. Gould & Lewis (1985) stated that an early focus on the users would result in good design results. This method includes working closely with the users to ask them what they want, modelling the users and their tasks, or also using guidelines derived from previous work. There is evidence that users find it easier to use an application when they are engaged in both the design and construction of it (Papert, 1980).

After this paragraph, I describe four topics regarding user-centred design: (i) '*Participatory design & co-design*' – which includes the final users as active participants in the technology design process; (ii) '*Cooperative inquiry*' – a method to research 'with' rather than 'on' people; (iii) '*Informant design method*s' – where children and adults are invited to inform the design throughout different stages of the design process; (iv) '*User-driven innovation*' – a method which positions users as a 'source of innovation'. All of these methods were used in this thesis, except the 'informants' layer where teenagers are seen as experts, informing the designers of critical issues related to their experience.

PARTICIPATORY DESIGN & CO-DESIGN

'Participatory design' incorporates several methods and theories while the core philosophy is to include the final users as active participants in the technology design process (Muller, 2003; Salen, 2007). Taxén and colleagues (2004) pointed out that 'Participatory design' is a strategic approach to producing user-oriented information technologies. 'Co-design' is an updated term for 'Participatory design' and descends from the work of Sanders and Stappers (2008) on co-creation and participatory design, who argue 'co-design' as mutual creativity as it is applied across the whole length of a design process and has developed several tools and methods to enable co-design in different product development settings. The purpose of 'co-design' is the collaboration between children and adults on designing together a prototype of a common idea.

COOPERATIVE INQUIRY

'Cooperative inquiry' is a method to research 'with' rather than 'on' people and usually includes adult users into the design process (Druin, 1999). However, Druin (1999) quickly found that these activities needed to be adapted and changed to suit teams that include children. Due to this reason and the topic of this thesis, this section concerns 'cooperative inquiry' involving children. In 'cooperative inquiry', children act as designers' full partners, and they

can share ideas and evaluations alongside with adults (Druin, 2002). 'Cooperative inquiry' is sometimes used as a modified form of 'participatory design', which encompasses sketching ideas with art supplies (paper, cardboard, glue) to create low-tech prototypes during the brainstorming process (Druin, 2002, 1999). It was found that these methods work for different age groups. The method had been adapted to suit different age groups, such as 10-13 years old (Knudtzon et al., 2003), and also younger children of 4-6 years old (Farber et al., 2002). With 'cooperative inquiry' we gain access into the children's practice; however, Knudtzon and colleagues (2003) pointed out the need of time and thus effort to establish a productive design team. Druin's seminal work on 'cooperative inquiry' (1998, 1999) and the Scandinavian approach to 'participatory design' in 2004 (Robertson & Good, 2004), have gained acceptance within the Interaction Design Children (IDC) community. Design methods such as derived from the 'cooperative inquiry' approach (Druin et al., 1998) and 'participatory design' (Greenbaum & Kyng, 1992) have been changed to document how children could participate as 'co-designers' (Iversen & Brodersen, 2008) in the process of developing new technology.

INFORMANT DESIGN METHODS

'Informant design methods' are a design methodology in which children and adults are invited to inform the design throughout different stages of the design process (Druin, 2002; JC Read et al., 2002).

Druin (2002) layered children's roles as participants in HCI work onto an onion model, where the relation of children to technology can vary from by merely being the end-user of a technology designed by adults, to a very active involvement as a member of the design team. She identified four different ways by which children can be involved throughout the development process: (i) as *users*, where they are observed in performing existing activities; (ii) as *testers*, where they are observed testing technologies and asked to provide feedback during interviews, think-aloud techniques; (iii) as *informants*, where they are seen as experts, informing the designers of critical issues related to their experience; and 4) as *design partners*, where they work as equal members of the design team, helping in identifying problems and solution to improve the technology. Druin (1999) also gives some practical advice for developers working with children, such as wearing informal clothing, sitting instead of standing, asking the children for their opinions and giving them time to articulate them, using informal language, and taking notes discreetly, as well as using brainstorming in the beginning of the design process to encourage a 'feeling that everything was possible' (Druin et al., 2001). In another approach, Read and colleagues (2002) offered a model showing the different

involvement of children along a power imbalance continuum ranging from (i) *facilitated design* – emphasis onto the domain expert both to initiate ideas and to take the lead in realising the design, with the design expert being in a facilitating role, (ii) *balanced design* – equal partnership between the two categories of participants, both engaged in realising the ideas, and then to (iii) *informant design* – to inform the design experts, and the design experts mostly realise the design.

USER-DRIVEN INNOVATION

The user-driven innovation method is mostly used by industry (Buur & Matthews, 2008) and positions users as a 'source of innovation' (Holmquist, 2004). According to Chang and Kaasinen (2011), it is important to adopt user-driven innovation approaches to capture user ideas that can be worked on further with designers. These face-to-face approaches have the power to facilitate participation as well as allowing HCI researchers to gather information that best translates the "user's everyday experiences" (Chang & Kaasinen, 2011).

2.2. THE MUSEUM EXPERIENCE

LEISURE TIME AND ENGAGEMENT

John Falk (2009) points out that people find leisure time as an opportunity to engage themselves in new concepts, spaces, and experiences, rather than relaxing under a palm tree at the beach. People's leisure time is supplied with experiences intended to promote a variety of mental diversions rather than just physical relaxation. When including museum tours, whether in school field trips or even in a short trip to visit a town, people often calculate the value of the experience before going ahead; people think about how they will benefit from the time invested in the selected museum. As Falk suggests, we immerse ourselves in pleasant experiences which promise to make us happier or more knowledgeable persons. Those experiences support and strengthen our spirit, and in general, make us feel fulfilled. Before going on a tour, most visitors are aware of the museum's benefits and begin the tour with expectations. These visitors' motivations, as well as their behaviours and existing memories, are highly correlated and are not separate aspects of the visitor experience. After an extent review of the literature about why people go to museums, Falk concludes that there are patterns related to museum visitors' motivations, however little agreement concerning how those patterns should be described and categorized. It is due to human nature our propensity to want our expectations met, and we work hard, often unconsciously, to satisfy them. However, unsatisfactory experiences can happen. The visitor notices that their experience was less than satisfying if expectations are not met. The following factors make some experiences and memories more notable and hence, memorable than others: the choice and control over the experience, the emotional nature of the experience, the context and appropriateness of what is encountered in the museum. Past museum experiences shape future museums experiences. These actions also contribute to other potential visitors' future visits.

VISITOR EXPERIENCE AND TECHNOLOGY

Visitors have been transforming from passive to active participants (Simon, 2010). Museums are increasingly integrating cutting-edge technology in their offerings; however, this does not mean that all interactive experiences are delivered and perceived successfully. There are cases where the visitor's mental model discords with the design of the exhibition that they are interacting with (D. Norman, 2013), changing the focus from the experience to its design, and interrupting the flow (Csikszentmihalyi, 1998); which eventually leads to frustration and

negative user experiences. While the spatial narrative might be present logically and consistently, not all visitors might choose to follow it, learn from it and engage with it (Stenglin, 2004), and "apart from the change in technology, there is a change in attitude, with visitors actively (rather than passively) seeking knowledge" (Mancini & Carreras, 2010, p. 60).

Traditionally, museums had various methods to promote visitor involvement such as wall labels, audio guides, guided tours, and brochures. Wall labels and brochures might be very well designed, but they will always be static, with a monologic interaction. Although audio guides usually deliver rich content and stories, they remain as a monologic communication channel, where users are not able to converse nor request further information. Guided tours have a more flexible touch, where visitors can have their questions answered directly by their designated tour guide; however, they are constrained by the tour time, availability of the guides, as well as their depth of knowledge on a particular subject. One of the daunting tasks is to design technological interventions in order to motivate visitors to participate and engage. Moreover, without some degree of interactivity, it is challenging for a museum to remain exciting and relevant to the young tech-savvy audience. Researchers are keen on exploring visitor experience and mobile guides; mainly because of the challenge of acquiring information at museums and due to the large data sets, which can be troublesome. The current guides are designed by design institutions or by the museums themselves through existent authoring-tools (Bellotti et al., 2013; Risseeuw et al., 2016; Rojas et al., 2014; Sintoris et al., 2014).

VISITORS ARE THE MUSEUM, AND THE MUSEUM IS THE VISITOR

As stated by Falk (2009), "the museum visitor experience is a dynamic process, a cycle with no real beginning, middle, or end all parts of the process are equally important if the public is to have their needs satisfied." (pp. 237). This author also referred that we usually see the museum visitor experience through two lenses: Lens #1 is about the museum, its content, and exhibits; Lens #2 is about the visitor, their demographics, visitor frequency, and social arrangement.

Regarding Lens #1, having a distinct interest in a subject matter of a museum is essential to determine who will visit, although it is not enough to explain who visits any given museum on any given day. Content is relevant in the sense that these institutions are an interesting place to visit; still, it is not the primary driving factor in influencing individuals to make a tour on a given day. For some visitors, not all, the museum experience is determined by the quality of exhibit design. As a result, seeing the museum solely through the lens of the

museum provides a surprisingly small degree of knowledge about the museum visitor experience.

Concerning Lens #2, it is clear that one could understand the museum visitor experience by knowing something about the people who come to the museum. The number of demographics, such as education, income, occupation, ethnicity, and age, has been found to correlate with museum-going positively. Nevertheless, those demographics provide a short explanation for museum-going, yielding a false sense of reason. These facts will not ever tell whether people will ever attend a museum tour. Beyond demographics, the museum relates to the visitor frequency and social arrangement; thus, these aspects have been much more helpful in understanding the museum visitor experience. Visitor frequency tells how many people visit the museum repeatedly, it is an action of the visitor that suggests some more profound characteristic that is significant for the visit to occur. Visitor's social arrangement yields some useful insight into how visitors may behave within the museum. Anyhow these ideas are too broad and unpredictable to understand the museum visitor experience in details. Family groups behave differently than adult groups and children groups, also when they are in pairs or larger groups.

Both lenses reveal some of what is essential to the museum experience. However, analysing the museum content as well as quantifying their visitors by demographics, frequency, or social arrangements, cannot adequately describe the museum experience. Falk also suggests that the museum visitor experience is situated within the moment when both these lenses become the same, where visitors are the museum, and the museum is the visitor. The museum and its content are fluid and changing.

To make museums engaging spaces for guests requires engaging them both before and after their visit. Museum curators need to work on strategies to engage the visitor beyond the physical boundaries of the visit. Besides the desire to build long-term memories for their visitors, a large number of museums want to be in touch with their visitors, since this way it will ensure future audiences. As we have seen, the trick to making a visitor return is to make them feel good about the experience taken. Guaranteeing that visitors feel they had a quality museum experience is as vital as reinforcing these feelings and make sure that all visitors feel good about having achieved their personal goals. In addition, having something to finish might be a good motivation for the visitor to return (a game, a collection, an activity, an assignment…).

FALK'S VISITOR EXPERIENCE MODEL

The realities of the museum also play a role in bending and shaping the individual's museum experience. The Falk's model (2009) regarding visitor experience takes into account that a visit to a museum develops long-term memories and meaning. This model yields that the expectations of each individual actively shape the museum experience had constructed previous the visit, based on their identity-related needs along with their expectations and views of the broader socio-cultural context. However, it is essential to take into consideration that the model could just quickly be the reverse, starting from an individual's memories. Falk considers that this model has the potential to allow museums to proactively lead the museum experience in better ways due to its encouragement to approach interaction with visitors.

The model starts with the first conceptualization of the idea that visiting a museum in one's leisure time could help to fill an identity-related need and concludes long after the museum visit ends through the individual's growth and enrichment of personal identity. In between, the individual's identity-related visit motivation drives the experience, becoming not only the reason for visiting but also the actual visit and the setting down of long-term memories. The model suggests that the so-called 'one size fits for all' does not apply to museums' visitors. Hence, the marketing goal of museums should not be a single promotional strategy. The model predicts that different motivations result in different existing understandings, suggesting that the institutions should try and segment audiences as a function of their identity-related motivations, starting with the five motivational categories proposed: (i) *Explorer*, (ii) *Facilitator*, (iii) *Experience Seeker*, (iv) *Professional/Hobbyist*, (v) *Recharger*. Studies from Falk reveals that each of the five categories represents a fundamental view by many visitors of what needs the museum best supports on any given day. Those five categories of visitor motivations do an essential job of representing the majority of leisure attributes most people currently assign to museum contexts.

The *Explorer* is seeking 'interesting things' – what guides the explorer in the quest is their own inner compass which is 'magnetized' by the visitors' unique prior knowledge, experience, and interests. Once inside the museum, they will know exactly what interests them. They are pleased to share what they have discovered, but they have a fear of being distracted by someone else's interests. They see museums as challenging intellectual places that have the potential for satisfying their personal curiosity and interest for the museum content.

The *Facilitator* is seeking 'interesting things for others' – their goals are to satisfy their needs for someone else and to help maximize the quality of what the other person experiences. They are interested in what their significant others find interesting and enjoyable. In some

cases, they allow children to direct the visit. They usually have the desire to be a good parent who places a high value on learning. They see museums as educational places where the family, especially children, could enjoy themselves and learn new things.

The *Experience Seeker's* trajectory motivation is a combination of the *Explorer* and the *Facilitator*. They are in search of what is most famous and interesting in the museum. Most *Experience Seekers* are first-time museum visitors. They will be attuned to see what they were meant to see, if they go to see a particular exhibit, their exhibit will be a real high for them and quite memorable. They see museums as a significant new attraction where anyone who seeks new experiences should visit. Hence, they reflect on how enjoyable the visit was. They want to be exposed to the things and ideas that demonstrate what is more important within a culture or community. These typical visitors are usually motivated to collect experiences, so they feel 'they have been there, done that' – their goal is to see what's iconic or famous on display. Being motivated by the idea of being in a culturally prominent place, a large part of their visitor motivations relates to having a good day with their relatives or friends, and desire to make memories of the experience. Therefore, they like to take and share pictures of their museum visitor experience. The usual *Experience Seeker* is hardly likely to return; still if satisfied, they are likely to spread the word about the experience taken and encourage others to visit.

The *Professionals/Hobbyists* enter museums with very particular, content-oriented interests. They typically hold an above-average understanding of the museum's content due to their professional as well as their avocation, and they usually visit the museum to satisfy a particular goal or objective. They see museums as places to go further specific intellectual needs.

The *Rechargers* focus on the gestalt of the day like *Experience Seekers*, although they are not so interested in having fun as they are in having a peaceful experience. If *Rechargers* encounters peace and psychological uplift, it will bring them a sensation of great pleasure and this feeling will remain in their memories. They see museums as places where they can be intellectually and spiritually recharged and rejuvenated.

This model predicts that different motivations result in different understandings. Even though every experience is unique, visitors with similar entering motivations are more likely to have similar museum experiences than are individuals entering with a very different identity-related visit motivation. Although *Facilitators* and *Experience Seekers* are almost always greatly influenced by the quality and focus of the exhibition's content, *Professional/Hobbyist* and *Rechargers* are much less. *Explorers* fall somewhere in between. Also, visitors enacting

of the roles of *Explorers*, *Experience Seekers*, and *Facilitators* are less task-oriented than those enacting as *Professional/Hobbyist* and *Rechargers*.

Although this museum visitor experience model will not let us predict with certainty what every visitor will do and remember all of the time, it would enable us to describe and predict the underlying trajectory of a significant percentage of museum visitor experience. Much of what affects the course of the visitor experience is not directly under control of the museum such as the knowledge, prior experience, social group, and visitor' interests. Although the details of what the visitor remembers will vary, the basic form and structure of their memories are likely to be predictable. We need to be aware that memory is always selective to understand how the long-terms meanings people make from their museum visit experience can be shaped by entering identity-related needs. The key to understanding what is recognized depends on the filters which every visitor brings with them to museums. These filters create the lens by which memory is formed and recalled. Depending on the visitor's current identity-related visit motivations, the same individual can engage with the same exhibitions in fundamentally different ways (as an *Explorer, Facilitator, Experience Seeker, Professional/Hobbyist, and Recharger*). After the tour, the visitor uses their visit experience to improve and change their sense of identity and thoughts of the museum along with, in a small but significant way, how society understands this and other museums. Museums invest considerable amounts in marketing (brochures, media placements); however, most of the public's knowledge and perceptions derive from word-of-mouth recommendations by past visitors.

This model was inspiring for this doctoral research as it suggests that visitors have different motivations and social context that impacts on their behaviour and challenge the 'one size fits all' approach to museum interpretation. Museums best practices suggest to segment audiences in groups concerning their motivations, social group, and expectations. As an audience group, teenagers are known, among museum professionals, as a difficult group to reach as they appear to be generally disinterested in what museums have to offer (see section 2.3. '*Teenagers as target audience*'). Teenagers, in comparison to other teenagers, would also have different entering motivations to visit a museum, which made me question if teenagers would differently behave when given different museum experiences. This model encouraged me to approach interaction with teenage visitors to classify and describe their behaviours with museum experiences, and whether they will be motivated to collect experiences as seen in the *Experience Seekers* category.

2.3. DIGITAL INTERACTIONS IN MUSEUMS

MUSEUMS AND TECHNOLOGY

Designing technology for museums which motivates visitors to participate and engage with it, is a challenging task. Today for museums to be more appealing to all generations, need to provide possibilities for visitors to take an active role in their spaces. The advent of Web 2.0 technologies allows the creation of new content. Thus, we are witnessing the passage from a communication of few-to-many people to many-to-many people. Projects such as Wikimedia Commons and Europeana 1914-1918 are classic examples of Web 2.0 projects. Therefore, web services such as wikis, social networks, and blogs exemplify the success and influence of Web 2.0 applications on western societies. Hence, these ideas of Web 2.0 inspired the term Museum 2.0 (Mensch & Mensch, 2010; Simon, 2010). Resources such as web-learning, audio tours, movie theatres/auditoriums, touch-based interactive exhibits, and even group-based video games are all of vital importance to the expansion of today's museums in both educational and marketable sense (Sayre & Wetterlund, 2008).

Museums have been trying to attract more visitors by offering new ways to engage them in their facilities by adding interactive content to their exhibitions. Through the use of new technologies, visitors can have further enriching and tailored experiences. It also lets the visitor be part of the museum experience in a natural way. These technologies can be web-based (Bernstein, 2008; Huhtamo, 2002; Lehn & Heath, 2005) or standalone mobile applications that promotes communication between the museums and their visitors. Many technologies are in use such as Quick Response (QR) codes (Bailey-Ross et al., 2016), Augmented Reality (AR) (Čopič Pucihar et al., 2016), Near Field Communication (NFC) technologies (Blöckner et al., 2009; Sintoris et al., 2014), Radio Frequency Identification (RFID) tags (Ghiani et al., 2009; Muchinenyika et al., 2014), Beacons (Nilsson, Blackwell, et al., 2016). These interaction approaches based on discovery are called 'dialogic interactivity' (Witcomb, 2003) which inspires visitors to explore open-ended results, in contrast to the expository model (visitor receives passive information: wall labels and brochures) and stimulus-response model (visitor can only simulate one correct answer to get a response).

MOBILE GUIDES

Museum audio guides dates back to the 1950s and were described as the standard method for providing visitors by short-wave radio broadcasts with content beyond wall labels,

where visitors could listen to a recorded audio program (Tallon & Walker, 2008). In the 1990s the visitors could access the audio information by typing numeric codes placed on artworks (Acoustiguide Group, 2014). Thus, visitors had more control about the information displayed by selecting the information about works they were interested in. Today, most museums that use audio guides use systems very similar to this last update. Museums today are engaging with new and interactive technologies, challenging the old paradigms of audio and human guides.

Some museums like children's museums provide graphical and interactive information inviting visitors to try them in order to learn and understand new concepts. These types of experiences encompassing several senses are generally accepted as very educational, engaging and memorable. Mobile guides have the particularity of enabling this kind of education as well as engaging and memorable experiences (Bailey-Ross et al., 2016), and only require minimal changes to the exhibition space. Mobile guides can contain many learning options to be tailored to each exhibition or categories of visitors, and they also have access to an unlimited amount of information on the internet that can expand an exhibit outside the museums' walls. Research conducted by Yao-Ting and colleagues (Yao-Ting Sung et al., 2010), in a national museum of history, revealed that during an exhibition, students (20 years old) with a mobile device interacted for a more extended period with the exhibition compared to other students without the device. This study also showed that using a mobile device inside a museum can increase the number of total interactions between visitors and the museum itself. Furthermore, a study by Vavoula and colleagues 2009) has shown that children (13-14 years old) who use mobile technology were motivated to ask relevant questions about the exhibition and argues that the museum tour allowed the student to explore the environment, with active inquiry and engagement.

Mobile guides in the form of interactive multimedia applications for smartphones or Augmented Reality (AR) / Virtual Reality (VR) immersive experiences are becoming favourite tools for museum tours (Damala et al., 2016; Hatpaz, 2016; Merritt, 2016) and are gradually replacing the traditional audio guide, as personal devices are becoming smaller, cheaper and more powerful. The BYOD approach (Bring Your Own Device) is an emerging tendency that allows museums visitors to access information that is available anywhere and at any time, including later usage outside of the museum (Song, 2014).

With the advent of the smartphone and app stores, museums frequently publish friendly apps to provide more information to the user.

Smithsonian[7] complement information already shown at the museum with a custom designed application for iPhone, Android and also a mobile version of their website to reach as many people as possible. In this app, it is possible not only to see information about the exhibition but also to share photos and comments about the exhibits. Moreover, they also offer an opportunity to discover the museum through a scavenger hunt app; therefore, users can have interactive and different ways to explore the museum.

The *American Museum of Natural History*[8] also has its own app. It encompasses turn-by-turn navigation inside a building, and the visitor has access to different exhibitions and tours, as Smithsonian app provides. Besides this, it also offers the possibility of sharing exhibitions through social networks.

Cuseum is one app designed for museums' visitors to replace audio guides. *Cuseum* is a mobile phone application that tracks visitors' movements throughout a particular museum. When visitors are near a particular beacon, the phone emanates a sound because they have reached a particular art piece which the application has information about. Once the visitor is alerted by the phone sound, digital information about the piece is given by sound, text, and images. Some museums such as Frick Collection and the Isabella Stewart Gardner Museums have avoided *Cuseum* technology for fear of it disrupting other visitors' quiet contemplation of the museum space, although those who have embraced *Cuseum* have found it to be broadly popular with college-aged visitors (Cannell, 2015).

Kurio is another museum guide for families which encompasses interactive tangibles, PDAs (personal digital assistants) and tabletop displays (Wakkary et al., 2009). While visitors explore the exhibition, they are making a 'journey through time' where they are invited to complete different tasks in the museum to travel back in time. As a result of the experiment in the field, the playful guide and narrative motivate visitors to discover the exhibition in a more careful way.

Sánchez and colleagues (2011) report on *Touch&Share* an NFC Tangible User Interface game for children to interact with stuffed animals of a local zoological museum. When users touch a tag, they can download the files (audio files, videos, text documents) from the tag and later watch this content either in their mobile phones or in a computer connected to the Internet. According to the authors, "the museum become alive, the pupils [9-13 years old] enjoyed the visit, and some schools requested to visit the museum because of the application."

[7] https://www.si.edu/mobile
[8] https://www.amnh.org/apps

In the discussion, the authors argue for the value of incorporating interaction in already existing objects through NFC.

Though, some studies have also revealed some of the limitations of using mobile devices. First, in terms of mobile devices between visitors and exhibits, compels spending time familiarizing themselves with the device and its application during the visit which prevent visitors from focusing on learning through the process of observing the exhibitions without stop (e.g., Mantyjarvi et al. 2006; Semper and Spasojevic 2002; Hsi 2003; Klopfer et al. 2005; Reynolds, Walker, and Speight 2010). There are also several studies about the advantages of using mobile devices as a supplemental learning tool in museums settings (e.g., Collins et al., 2008; Yao-Ting Sung et al., 2010; Y.-T. Sung et al., 2010; Vavoula et al., 2009.

A study on the usage of mobile guides (Helal et al., 2013) highlighted that the visitor's (adults and children) firsts motivations for using a mobile guide are (i) to access additional information about the museum exhibits, (ii) to learn about a specific artist/exhibition and (iii) the curiosity to try the guide itself. In another study conducted at the British Museum (Mannion et al., 2016), visitors suggested for the audio guides (i) to contain the voice of the curator and recognized experts, (ii) have plenty of stops, (iii) not overwhelm the visitor with too much information and (iv)) provide more information than those stated in the labels.

DIGITAL STORYTELLING APPROACHES

Digital storytelling is a vast field, crossing various domains, from sociology to education, such as memories conservation. Digital storytelling is a powerful tool for turning visitors from passive to active viewers as Mulholland and Collins (2002) noted. They affirm that technology and storytelling should support learning and creativity as well as active interpretation in the cultural domain. Nowadays, numerous digital storytelling experiences in museums are emerging and enabling the visitor to engage with the exhibition; the most relevant to our work are cited below.

1001stories[9] is a framework encompassing multimedia, effective and affordable content, multi-technology and multi-format (for mobile use 'on the go'). The content can be available on different channels (web and smartphones), producing different formats for different user experiences. This project makes it possible to spread museum stories across any physical boundaries.

[9] http://www.storymuseum.org.uk/stories/audio-stories/

CHESS (Cultural Heritage Experiences through Socio-personal interactions and Storytelling)[10] is a project which uses information about cultural exhibits to create customized stories which guide visitors through a museum aspiring to create a sense of wonder in the visitor's experience. Museums build a range of personas and then offer a series of different experiences. Each visitor gets their own unique narrative to follow, guided via a tablet, through a personalized story that connects museum artefacts, exhibits, and external collections based on the interests of the individual. If visitors skip something or show a deep interest in a particular type of content, this information can be used to adapt tour content as the visitor moves through the museum. It employs pervasive gaming techniques, reaching from narrations to augmented reality on smartphones. The project follows a plot-based approach, where curators, museum staff, and scriptwriters write stories around selected museum theme (Katifori et al., 2014). A beta of the program was in trial at the Cite de l'Espace Museum in Toulouse, France, and at the Acropolis Museum in Athens, Greece. This system is of great interests to this doctoral research because, even though museum experts can create the content, visitors assume the role of one persona depending on their interests. These categorization happens regarding their preferences and also their visitor types (Antoniou & Lepouras, 2010; Roussou et al., 2013).

The MeSch technology is a toolkit which enables museums to create their smart exhibitions. This is allowed by RFID tags using NFC which are integrated within each object. The digital experience 'The Hague and the Atlantic Wall: War in the City of Peace', deployed in Museon – The Hague (Netherlands), was created integrating all the MeSch[11] Technology (Damala et al., 2016). This particular exhibition referred to the times between war and peace. Visiting stations were arranged, where visitors could hear different perspectives of the narratives through different objects replicated in each station. These objects could be picked at the beginning of the exhibition or each station and were the essential element to unlock the narratives. This project is of particular importance for this thesis because it does not only use cutting-edge technologies through tangible exhibits which enable the visitor to have a more enriching experience with the exhibits, but it also does enable the museum experts to insert their content to create narratives which per se would be more attractive to the visitor (Damala et al., 2016).

[10] http://www.chessexperience.eu/
[11] http://mesch-project.eu/

PLAYFUL INTERACTION AND ENTERTAINMENT IN MUSEUMS

CHALLENGING KNOWLEDGE

Museums are becoming hubs where children can experience various kind of entertainment while they enrich their knowledge and solving challenges by themselves (J. H. Falk & Dierking, 2000). While the use of mobile devices to enhance and enrich museum visits has a long history (Barton & Kindberg, 2001; Cahill et al., 2011; Fleck et al., 2002; Sherry Hsi & Fait, 2005; Koushik et al., 2010; Martin & Trummer, 2005; Marty et al., 2013; Sánchez et al., 2011), the idea that entertainment and gaming can play an equal role alongside with the learning mission of most museums is a more recent approach. Museums are recognized as a fertile arena for the gamification challenge (Pierroux et al., 2007). Moreover, Yao-Ting Sung et al. (2010) found that problem-solving on a mobile device amplified visitors' motivation for learning due to their need to search for details in order to correctly answer the challenges that were proposed. Hereinafter, games for museums that challenge the visitor's knowledge through quizzes are listed along with their mainly research findings.

In *QuesTinSitu* (Melero et al., 2015), students visit specific locations in order to solve specific questions. The study highlights that group size and the role of smart devices affect visitors' attention and participation in group-based mobile learning. In particular, visitors in smaller groups enjoyed the activity more than bigger groups. To solidify this conclusion, the study from Schwabe and colleagues (2005) also obtained differences regarding immersion and enjoyment in groups of two and four people. Moreover, in this particular study, it was verified, through the use of post-questionnaires, that the visitors who were interacting with the smartphones were more focused on the activity, being more engaged and concentrated compared to those who did not.

Schaller and Flagg (2013) designed an iPhone/Android game for pre-teens to be played at Maryland Science Center. The game requires participants to collect cards throughout the museum by finding three-digit codes and answering multiple-choice questions in order to earn cards. The results of the study show us that two-thirds of the participants felt that using the mobile game increased their enjoyment about the exhibit, and almost all (88%) reported that using the mobile game helped them to learn more about the exhibit than without mobile technologies. The reports from the visitors are valuable insights since we can reflect on the mobile games' effect on learning experience and personal enjoyment.

In 2007 at the Minnesota Historical Society, it was launched an exhibition entitled *Minnesota 150* to celebrate the state's 150th anniversary. To make things interesting, there was

an auditorium sized trivia game that would involve several players at the same time. Players would compete against each other through multiple question choice trivia questions about the state's history, where they were frequently encouraged by several images and video clips for most of the questions. This sort of experience not only made the learning about the state's history more 'fun' by turning the visitors' experience in a game but also allowed the players to learn meaningful content about the state from one another by sharing their pre-existing knowledge with each other (Sayre & Wetterlund, 2008).

TREASURE HUNTING

Mystery and treasure-hunting (Cabrera et al., 2005; Dini et al., 2007) as well as problem solving tasks have the potential to engage, entertain and scaffold visitors' learning through museum contexts (Bakken & Pierroux, 2015; Charitonos et al., 2012; O'Hara et al., 2007; Pierroux et al., 2007; Yao-Ting Sung et al., 2010). In the past few decades, a mass of game-based museum programs has been designed for different media platforms and visitor types, such of them are reported below.

Ghosts of a Chance was implemented at the Smithsonial Amercian Art Museum (SAAM), in which the community was encouraged to participate using the internet, phone, email and face-to-face interaction (Bath Goodlander, 2009). This game involved a sequence of clues and puzzles and was very well accepted among adults and teenagers. Despite the fact it was not educational, it encouraged visitors to think about art in a fun and social way, which is a great interest for this research as I do not measure formal learning, but the engaging experience in the museum with an awareness of the message the museum wants to communicate to visitors.

In *Family Quest*[12], playful app designed for the Rijksmuseum in Amsterdam, an art and history museum, two to four players can play the game inside the museum, each one on their digital device. The challenge is to find secrets within the exhibits.

The *Capture the Museum – game*[13] at the National Museum of Scotland in Edinburgh (natural history and culture museum) is a group game where two teams compete and play a live game where the parties capture and hold numerous physical locations to win.

MuseUs (Coenen et al., 2013) is a pervasive serious game for the learning of cultural heritage. Through the Graphic User Interface (GUI) of the smartphone application, museum visitors could achieve two things by scanning a QR code near an art piece. Firstly, they could

[12] https://itunes.apple.com/gb/app/rijksmuseum/id621307961?mt=8
[13] http://www.capturethemuseum.com

view more information about that specific piece and secondly, they could match the exhibit to a frame in the virtual space of the mobile application. In this study, users found the application to be beneficial in the context of children's learning; this considering that they were prompted to look at the exhibits from diverse viewpoints. Moreover, it highlighted immersion as an essential aspect to keep in mind when designing serious games for learning. The study also highlights the importance of limiting the search to search a single achievable area; otherwise, the user could potentially find the challenge to be burdensome. This suggestion was incorporated in the design of the *Memories of Carvalhal's Palace* (MoCP) dual experience (chapter #4), where participants could quickly achieve the areas to go further in the experience.

STORYTELLING & GAMIFICATION

A lot has been done and said about adventures in museums, from blockbuster films – *Night in the Museum* and its sequels – to books – Eco's *Foucault's Pendulum* (Eco, 2007), and Brown's *The Da Vinci Code* (Brown, 2009). Stories and games can boost the learning goals of the museum while enhancing the playful aspects of the visit. Previous research demonstrates that storytelling and game-based approaches benefits museums by promoting joyful and exciting experiences, which have the potential to support meaningful learning (Edwards & Schaller, 2007; Ioannidis et al., 2013). Moreover, games and storytelling are two of the most used techniques to engage young and adult audiences as museum visitors (Damala et al., 2016; Katifori et al., 2014; Nilsson, Hogsden, et al., 2016; Xhembulla et al., 2014). Aware of the extended conversation between ludologists and narratologists, in defining driving strategies and building blocks in games versus narratives (E. J. Aarseth, 1997, 2004; Bogost, 2010; Jenkins, 2004; Jull, 2001; Laurel, 1991; Murray, 2004; Ryan & Rebreyend, 2013; Zimmerman, 2004), this research does not draw a straight line between game and story approaches. This research follows Aarseth (2012) approach, supporting the theory that games and stories should work together to satisfy and engage players in meaningful and memorable experiences. Several inspiring research projects that do not make a clear-cut distinction between game elements and story, hence instead fuse the two approaches into a single application are reported below.

Cabrera and colleagues (2005) built an interactive museum guide called *Mystery in the Museum*, at historical/cultural museums, which allowed students to play and perform tasks related to certain exhibits. In this activity, groups of students collaborate together to solve a mystery inside the museum, interacting through mobile devices. Each group receives different pieces of information through the mobile device and plays a role in the story. At the end of the visit they have to join and discuss together about the different clues they have collected,

rebuilding the story and trying to solve the mystery. In this experiment, some students (13-19 years old) lost interest in the interactive guide due to the complexity of the tasks, while others switched the focus from the displayed exhibits to the handheld computers. *Mystery in the Museum* stimulates children's imagination, the plot of this game-based approach involves some puzzles that relate to the exhibits. The most typical examples include scrabbled images of specific exhibits and verses from manuscripts of the museum. The authors argued that they might have built a tour led by the digital device instead by the exhibits displayed in the museum. That is because the players interacted more with the device than with the exhibits in order to solve the given quests. This insight was of great importance for the design of the MoCP (chapter #4), more precisely the game-based strategy *Haunted Encounters*, as the visitors should look at the exhibits in the shelf in order to correctly answer a question on the smartphone.

Ghost Detector (Nilsson, Blackwell, et al., 2016) is a story-driven and an educational location-based museum game for children that utilizes beacons. In this game, ghosts of various museum exhibits appear on the screen of the young visitors' mobile device and challenges children to find the exhibits that the ghosts are representing. While evaluating this game, children were observed running through the corridors, paying attention to the feedback on the smartphone as well as the exhibits surrounding them. This study highlights the introduction of the ubiquitous game undoubtedly influenced that level of excitement and engagement with the museum premises.

Intrigue at the museum (Xhembulla et al., 2014) is a plot-driven mobile game for children structured around exploration and tasks performance. It is a single-player game, and its plot invites visitors to search for a thief in the museum among a set of virtual characters. Clues are given to the players and as they solve riddles after scanning tags deployed in the building. Following a constructivist approach, the game allows children to explore the museum environment freely, according to their interests and agenda. This paper shows that location-based mobile games might represent a relevant learning resource in a museum setting while promoting engagement and entertainment.

2.4. TEENAGERS AS TARGET AUDIENCE

Recent work considers teenagers as being different from both children and adults perspectives (Daniel Fitton et al., 2013). The teenage brain is in a position of continual change (Ruder, 2008) and hence it behaves differently from children and adults. It is hypothesized that some methods that flirt with extreme responses and actions might not be suitable for teenage use. Teenagers might be the best evaluators for technologies, and also the best designer of products due to their creative risk-taking minds (Read et al., 2013). Technology can foster meaningful experiences, creating a closer relationship between the user and the content.

The 'Generation Z' (13-18 years old) is especially seen as quite different from previous generations, particularly regarding their beliefs and behaviours (Wikia, 2013). In fact, Wikia (2013) reports that this 'Generation Z' is more and more engaged with open platforms. Besides, more studies argue that when working with this age group, emphasis should be placed on producing combined communication policies that connect the use of interactive technologies with the more conventional media channels (Napoli & Ewing, 2000). This generation is identified as an audience group that is often excluded from a museum's curatorial strategies (Tzibazi, 2013) and appears to be generally disinterested in what museums might offer. In return, museums often seem to ignore them. This exclusion has a profound impact, this considering that the design of interpretive experiences in museums is no longer sensitive to this group's specific interests and needs, this also limits a museum's potential to create interpretative experiences that have real pedagogical relevance (Tzibazi, 2013).

As the reader can check in this section, there have been several definitions for teenagers (13-18 years old) across times (2000-2013) which inform us that this group has always been seen as different than the other age groups. In addition, along these years I came across several research papers that refer to their teenage sample with different names and ages, such as (i) teenagers could range from the age of 10 to 19; (ii) users from 7-16 are seen as children; (iii) users from 16-19 are described as older teenagers, (iv) and also from 13-19 are described as a young audience. And here is where my work as its focus: on older teens/young audience from 15-19 years old (as this was the specific sample I got from Madeira Island and Porto schools).

TEENAGERS AS AN UNDERSTUDIED GROUP WITHIN THE INTERACTION-DESIGN AND CHILDREN FIELD

Research within the field of Interaction Design and Children (IDC) is often centred on the evaluation of existing and novel interactive technologies. The majority of these works have the focus on children age 4-11, which leaves a gap in the literature for children 12-17. As argued by Yarosh and colleagues (2011), "investigating and addressing the needs of these groups would expand the body of IDC work and provide avenues for new insight and innovation." Also, a study on Snapchat highlighted that it is essential to include teenagers in the discussion since they are experts on some of the social platforms (Schneider et al., 2012). Additionally, Katterfeldt and colleagues (2012) argued that this target group "requires more attention in research and there is a need for appropriate methods to involve them in design processes."

However, because teens represent a rapidly growing group of technology (Amanda Lenhart, 2015), researchers have sought new ways to involve them more fully in the design process (Dan Fitton et al., 2014; Norooz et al., 2015; Sustar et al., 2013; Winterburn et al., 2016). Moreover, methods for carrying research with teenagers within the interaction design has been discussed (Read et al., 2013). Examples of studies with teenagers are little, but include: observations and interviews with older teens (16-19 years old) (Berg et al., 2003) contextual design to understand teenagers (Kangas & Kinnunen, 2005), ethnographic methods (Sacher & Loudon, 2002), participatory approaches (10-12 years old) (Labrune & Mackay, 2006), or they engage teens in limited design roles, as end-users or informants in focus groups (Fisher et al., 2004; Poole & Peyton, 2013). In 2011, Read and colleagues (2011) described a study of 'coolness' with two different age groups of teenagers (11-12; 14-15 years old) through designs of an interactive application. The results revealed differences between younger and older groups as well as between genders (Livingstone & Helsper, 2007). Teenagers and participatory design within museum studies are also covered by some papers in the IDC community, as the case of the study 'Digital Natives' (Iversen & Smith, 2012b) where teens (15-19 years old) collaborated with designers, programmers, anthropologists and museum curators to create four digital installations for an exhibition. The case study 'Gaming the Museum' (Dindler et al., 2010) is another rare example of a study that started from the everyday practices of 14-15 years old teens where computer games and online communities were chosen to start a process for creating a game for a museum.

ACTIVE INVOLVEMENT OF TEENAGERS IN THE DESIGN PROCESS

Drawing on several key studies, Tzibazi also suggests that it is not only museums that ignore a younger audience (ages 13 to 19), members of this group seem to be generally disinterested in what museums can offer. In response to this gap, Tzibazi (2013) suggests involving youths through Participatory Action Research (PAR) and as a means of documenting their ideas and interests concerning museums.

Moreover, Hall and Bannon's (2005) study is particularly vested in demonstrating that cooperative design methods have the potential to support the successful introduction of interactive digital technology in museums. According to the authors, in a context where strategies have been mostly focused on the "functionality of [the] technology" (p. 214), the use of cooperative methods opens space for an in-depth understanding of an audience's specific desires and needs. However, apart from Hall and Bannon (2005), the work of Dindler and colleagues (2010) and the work of Ciolfi and Petrelli (2016), the active involvement of specific audiences in the ideation of interactive technologies for museums is lacking further development.

The work reported above echoes a gap that can be found within the field of HCI more broadly. For example, there are comparatively fewer studies reporting on the active involvement of teenage users. Those that are reported, rarely position teenagers as sources of inspiration and information for design, as in the studies reported by Batson and Feinberg (2006), Karin Danielsson and Charlotte Wiberg (2006). On the other hand, Katterfeldt et al. (2012), suggest that when teenagers are the subject of research, the employed user-centred design methods tend to produce an interpretation of their demands and needs without however leveraging on their direct contribution. Also, some authors suggest that teenagers will soon become adults and should, therefore, be involved in the design of future technologies (Daniel Fitton et al., 2013).

CO-DESIGNING WITH AND FOR TEENAGERS

There is little literature on designing for and with teenagers, and as addressed by Read et al. (2011), some of the reasons are: understating design for non-adults is still entirely new, and thus there is some catching up to be done, access teenagers are quite difficult, the worlds that teenagers live are quite tough to get in. Another challenge of co-designing with teens is logistical, since teens are often busy with extracurricular activities such as sports, after-school clubs, or part-time jobs and cannot devote the time required (Read et al., 2013). Other

challenges are related to adolescence as a stage in human psychosocial development. For example, teens may not actively participate in design research because they do not feel capable of providing adequate data to researchers. They are also uncomfortable about the research environment or concerned with appearing 'different' (Isomursu et al., 2004, 2003; Poole & Peyton, 2013).

Druin (1998) suggested that working with children in designing, evaluating or co-designing something can offer us a plethora view of their world. Working with children can help us establish new methodologies, it requires us to "stop and listen, and learn to collaborate with children of all ages." Although there are different opinions about what role can children have in the design process, that will be discussed below, most people agree that children can provide useful insights for the design process as being active (Druin, 1998) and having less active roles as informants (Scaife et al., 1997). Under these views, Scaife and colleagues (1997) see children as '(native) informants' as they are "aware of aspects of learning/teaching practices that we are not and which we need to be told of."

Vines and colleagues (2013) described goals of participation in design processes within Human-Computer Interaction (HCI) such as sharing control, individual, organizational and technological change, and also sharing expertise through boundary objects. Boundary objects (Star & Griesemer, 1989) help designers to appreciate users as a source of information and having specific expertise that should be shared and exchanged (Carroll & Rosson, 2007). Vines and colleagues (2013) additionally state that people are skillful and resourceful, and researchers should establish ways for this knowledge to be shared, communicated and embodied in the design of technology. Also, new technologies come with new audiences, and thus new perspectives on what design could and should be.

Cooperative inquiry has been used successfully with children, 7-16 years old (DiSalvo et al., 2013; Eladhari & Mateas, 2008; Gee, 2008; Isomursu et al., 2004; Karin Danielsson & Charlotte Wiberg, 2006; Scaife et al., 1997) for almost two decades. However, co-design with teenagers (13-17 years old) remains a less explored research area (Read et al., 2013). The challenges differ as the ages of children differ.

Participatory design has gained new user groups such as teens (Toth et al., 2012). Nevertheless, Hansen & Iversen (2013) stated that the studies of how users are engaged in the design process are still uncovered. Moreover, Dindler and colleagues (2010) have found inspirations in the engagement of children regarding games and online communities.

Participatory design and cooperative inquiry (Alborzi et al., 2000; Guha et al., 2005) advocate the ideal of children as design partners, suggesting greater equality between adults

and children. As informants and design partners, children are significant contributors to the design process. Nevertheless, these two approaches present some difficulties, such as the many numbers of children means many numbers of conflicting ideas and outputs that need to be rationalised (Read et al., 2005), and the design activities are often unbalanced regarding skills and knowledge. The application of informant design, participatory design, and cooperative inquiry methods with children as designers have become a popular means for the development of interactive computer products (Druin, 1998; Read et al., 2002).

Involving Cultural Heritage Professionals To Design Museum Experiences For Teenagers

Cultural Heritage Professionals (CHPs) are responsible for shaping museum experiences and collections (Ciolfi & Petrelli, 2016), and should be involved in the ideation of interactive tools as active players in the development of the technology design process. There are several studies that involved CHPs in the design of interactive interpretative exhibitions. Maye and colleagues (2014) report how CHPs engage in the design of interactive exhibitions in terms of their attitudes, processes, understanding, and expectations of technology. These researchers identified a gap regarding the know-how of CHPs in the development of interactive exhibitions, their design motivations and their attitudes towards technology. Museum and cultural heritage research has been focused on the engagement of the visitor experience of interactive exhibitions and how this can be supported and enhanced, rather than on the design process and practices of CHPs who create the interactive exhibitions. In HCI, existing literature examines the design processes involved in creating interactive museum experiences (Ciolfi & McLoughlin, 2012; Ferris et al., 2004), with examples of work that adopted participatory design or user-centred approaches (Bossen et al., 2012). Other examples see the inclusion of visitors and CHPs within the design team, providing the curatorial goals and the educational missions of the museum, as well as providing expert advice on content (Taxén, 2004). Hornecker and colleagues (2013) examined two aspects of CHPs work practices regarding interactive exhibits: their attitudes and perspectives, in particular, their values, goals and aspirations to create exhibitions; and their current resources and methods to create and implement interactive digital exhibitions. This study found that CHPs showed a strong interest in incorporating digital interactive exhibits into their museum exhibitions. For the smaller museums, the desire to include digital exhibits was driven by the perceived visitor expectation of being up-to-date. Including digital technology can be seen as the desire to communicate invisible material, making visitors more aware of their surroundings. However, there is a

conflict concerning understanding what is achievable with digital interactive exhibits and its disadvantages, such as high costs, maintenance issues, timely design, and distraction to visitors. Hornecker and colleagues (2013) also argue that this challenge could be addressed through authoring tools for digital fabrication, which focuses on making low-cost, rapid prototyping accessible for the general public as well as helping curators and designers to develop interactive exhibits. Many museums opt to outsource digital experience development to designers and engineers, however not all the museums have adequate funding available for these services and solutions. Alternatively, there is a range of free digital interactive media tools (QR codes and Augmented Reality apps) that museums and CHPs could use to create and deliver digital content to their audiences without outsourcing.

However, and as noted by Hornecker in another study (2008), if interactive tools are difficult to use, they can distract visitors from engaging with heritage exhibits. From another point of view, and concerning this authoring tools approach, Avram and Maye (2016) report on a collection of co-designed case studies and methods framed for CHPs to help them to create their own interactive exhibitions. This co-design resource integrates an authoring tool and a plug-and-play hardware and software platform (the meSch kit). This resource was created thanks to the diversity of the curators' background and professional skills, and also a possibility due to resources of the institutions.

It is crucial to involve CHPs in the design process to attract teenagers, given they are the adults of tomorrow, and a future museum-going audience which is currently neglected by curatorial strategies. Within the frame of HCI, there are approaches for designing interactive exhibitions which involve visitors and other stakeholders as informants on the design to create user-centred approaches (Ferris et al., 2004; Iversen & Smith, 2012a; Taxén, 2004). CHPs have seldom been involved in the design of such technologies, and since they are an integral part of the museum, integrating them in the development process of such technologies will additionally create museum activities (Maye et al., 2017). Co-design methods and techniques have been deployed in the design of technology for cultural heritage as a means to commence novel museum engagement exhibitions and programs (Bossen et al., 2012; Roussou et al., 2007; Taxén, 2004).

Chapter #3
METHODOLOGY

This chapter comprises the studies conducted with teenagers and museums, and the distilled series of requirements for an enjoyable museum experience – one that catches the attention of teenagers and promotes awareness of the museum message. Firstly, I studied the interests of teenagers in terms of how/what they would improve in a museum tour so that the tour was more appealing to them. I did this under two topics: '*Understanding teens and their museum experiences'*, which encompassed two studies (studies #1-2), and '*Framework for co-designing mobile museum experiences'*, which encompassed three studies (studies #3-5). Secondly, I studied how museums and curators perceive teenagers as an audience group under the topic '*Understanding how museum professionals see teenagers as visitors'*, which encompassed two studies (studies #6-7). On the one hand, the teenagers enlightened us as to the mechanics of the experiences that would be appealing for them, while on the other hand, museum professionals guided us through the kind of content and messages they wanted to convey.

Hereinafter, I describe firstly the museums involved in this research and, then, the above topics and studies accordingly.

3.1. A COLLABORATIVE MUSEUM STUDY

During the development of this work, I had the opportunity to collaborate with various science museums on the island of Madeira and in Porto: the Natural History Museum of Funchal and the Medicine and Engineering nucleus from the University of Porto. These two museums from the University of Porto were partners in a two-week activity plan for a summer camp at the Junior University of Porto, which I used as a research study to engage more teens in this doctoral research. I collected teens' impressions generally from these three institutions. The final digital interactive artefact, *Memories of Carvalhal's Palace* (in the next chapter) is specific to just one museum: the Natural History Museum of Funchal. These three institutions are described hereinafter.

NATURAL HISTORY MUSEUM OF FUNCHAL

The Natural History Museum of Funchal (NHMF) is not only the sole museum dedicated to natural history on the island of Madeira but is also a very striking venue (Figures 3-4). The museum building, dating back to the 18th century, was originally a distinguished palace with a warm Victorian atmosphere (wooden floors and ample doors that allowed women to pass through while wearing ballgowns). It is rich in diverse content from around the island, such as a world-renowned millenary forest protected by UNESCO as well as an abundance of marine life and maritime patrimony. The natural history content is distributed throughout six rooms with mammal, reptile, and geology collections, one aquarium with live animals, and one garden of aromatic and medicinal plants. The natural heritage of the island is embedded during the earlier stage of primary school, when children visit the NHMF at least twice a year to learn about and appreciate their inheritance. The NHMF offers various guided tours for children and adults, though it lacks appropriate guidelines for teens. Although the museum is full of diverse and rich content, the experience of visitors (especially teens) can be enhanced through the use of recent technological advancements in interactive spaces.

My original ethnographic data on teenagers in museums came from having access to the NHMF's visitor numbers. The museum is typically visited by school field trips (children and teenagers), and locals and tourists (children, adults, and seniors). Teenagers from 15-17 are a difficult group to catch their attention due to their lack of interest and focus towards the exhibits since they visit the museum as the part of school field trips without being keen to repeat the tour.

Figure 3. *One of the rooms from the Natural History Museum of Funchal.*

Figure 4. *Garden of Aromatic Plants from the Natural History Museum of Funchal.*

History Of Medicine Museum From The University Of Porto

This institution contains eight rooms and one Art gallery (Fig. 5). The rooms are dedicated to pre-historic medicine, primitive medicine, popular medicine, the medicine of ancient civilizations, and medieval medicines, enhancing the medicine of the 17th and 20th centuries. It comprises a vast collection of instruments, most of which are kept in elaborate cases. It also displays portraits, caricatures, personal and institutional objects, and documents from the teachers of the Medical School of Porto. The central corridor of this museum – a space from which the exhibit rooms open – holds a collection of essential 19th-century and current Portuguese art.

Figure 5. *Two of the rooms from the Museum of History of Medicine from the University of Porto.*

ENGINEERING MUSEUM NUCLEUS FROM THE UNIVERSITY OF PORTO

The Department of Civil Engineering from the Faculty of Engineering of the University of Porto offers a museum hall that contains a collection of topographical and astronomical instruments to support teaching and research (Fig. 6). The acquisition of some of this equipment happened at the beginning of the 19th century. Only two corridors from this collection were used: those related to topography.

Figure 6. *Two corridors from the Museum Nucleus of Engineering from the University of Porto*

3.2. UNDERSTANDING TEENS AND THEIR MUSEUMS EXPERIENCES

Here, the main goal is to understand how teenagers perceive museums' offerings and how interactive technologies could enhance their overall experiences at a museum. For this first stage, I carried two studies. Teenagers were situated as informants, and developers of museum experiences. In the first study, a total of 130 teenagers acted as informants during a focus group that sought to elicit their thoughts on engaging museum experiences at the Natural History Museum of Funchal (study #1). Finally, in the second study, 13 teenagers worked as developers in the creation of mobile experiences for the museums of the University of Porto (Engineering Museum Nucleus and the History of Medicine Museum), assisted by the HP Reveal Studio, an augmented reality tool (study #2).

STUDY #1: FOCUS GROUPS

Following Falk's model of visitor experience (2009), I hypothesised that teenagers of 15-17 years old would fall into the *Experience Seeker's* category. This type of visitors is usually motivated to collect an experience. In order to verify this hypothesis, I created a focus group with 130 teenagers (15-17 years old) to gather their thoughts about museums and what they would add to a museum to make their visit more enjoyable. From the data gathered from these focus groups, the assumption was verified: teenagers of 15-17 of age could be seen as experience seekers. Details of the study are reported below.

SAMPLE

After obtaining the approval of one secondary school to participate in this study and with the collaboration of its teachers, 130 teenagers (96 males, 34 females) 15-17 years of age from 7 classes (informatics and multimedia classes) were assigned to perform the study.

PROCEDURE

The focus groups took place inside the participants' classrooms. At the time I was conducting other research study and teachers allowed me 90min in the classroom with the participants, which gave me a slot of 20min with them to make a concept validation about if researching museums experiences for teenagers will be interesting from their point of view.

Nine slots of a 20-min focus group were performed, having around 14 participants per session. During these focus groups, and to make better use of time, I asked two simple questions which sparked a discussion among the participants. Those questions were as follows:

Q1) *What do you think about museums?* – To collect information regarding whether they like to visit these institutions and in what situations they usually go to museums.

Q2) *How do you think museums could enhance your experience at the museum to be more enjoyable?* – To collect information about which kind of experiences they would like to have inside museums.

ANALYSIS

During the sessions, I only asked the two questions above mentioned and audio recorded the discussion that emerged among the participants. These recordings were transcribed and the expressions were categorized into groups using Thematic Analysis.

RESULTS

Participants had multiple verbal expressions each, this is why I ended up with a total of 224 expressions for the Q1 and 443 for the Q2. When a participant came with an answer, the others agreed or disagreed, which sparkle the discussion during those 20min.

Q1) WHAT DO YOU THINK ABOUT MUSEUMS?

Regarding the Q1, I transcribed a total of 3 related expressions which were verbally referred 224 times by the participants. These expressions were grouped into one main category (Table 1). In general, participants think that going to museums is a good way to learn, although they "usually don't go there frequently". Participants related museums with the word 'boring', considering museum visits as a mundane activity. All 130 participants stated that as a general rule, museums do not show anything new, which implies that these young participants do not want to visit them, or they only visit them when they are on holiday with their parents. Nevertheless, even when they are on vacation, these young people only visit the museums located outside of their region in order to know other cultures. Four participants have expressed that they would like to try an interactive museum; however, they are "not aware of any".

Table 1. *Expressions of the 130 participants related to the question: What do you think about museums?*

Categories	Expressions	Times mentioned	Total
BORING	boring	130	224
	nothing moves	47	
	not appealing	47	

Q2) How do you think museums could enhance your experience and make it more enjoyable?

Concerning Q2, I transcribed 14 expressions that were expressed 443 times. These expressions were then grouped into four categories: (i) *Interaction*, (ii) *Multimedia*, (iii) *Experiences*, and (iv) *Interests* (Table 2).

When inside the museum premises, participants showed the desire to interact (202 expressions) through cutting-edge technologies, virtual reality and also playing games in order to have a good time there. According to these participants, games play a huge role in engaging people, and during the discussion I heard the following expressions "*It would be fun to explore a museum through a game. It would be engaging because the games are engaging. Hence the museums will become charming places*"; "*I could go to a museum taking a tour by a digital game to have fun and to be the best and also the fastest one!*". Likewise, the integration of social media and pictures sharing were referred through such expressions as "*If I saw a picture taken in the museum in my Facebook or Instagram I would go there for sure to try it*"; "*Taking pictures would be fun also as Snapchat does*". The latter is regarding the augmented reality effects that this social network, Snapchat, offers to their users.

These young participants pointed out that integrating multimedia (146 expressions) in the museums could appeal more to their generation as well as fulfilling their expectation to interact. Participants expressed interest towards integrating videos and digital content and interaction in the museum with expressions such as "*the integration of cutting edge technologies would be for sure more appealing for museums and teenagers alike!*"; "*The museums are usually boring, and with the implementation of treasure hunts they could be more attractive to visit and to spend a while*"; "*Of course I would visit a museum empowered with technology!*".

Participants pointed out that museums would be more engaging places if they were offered some experiences for them to try out such us unusual museum's events and different guided tours (55 expressions). They realize that the museums' advertisements do not reach them, hence they are less interested in these cultural institutions.

Participants showed me that they would be more involved with a museum if this one was related to their personal interests (40 expressions) in order to fulfil their intellectual needs, highlighting "*if it is a theme that I like, I am confident that I am going to enjoy the visit*". They mostly referred to photography, football, and electricity as some of their interests inside a museum.

Table 2. *Expressions of the 130 participants related to the question: How do you think museums could enhance your experience at the museum to be more enjoyable?*

Categories	Expressions	Times mentioned	Total
INTERACTION	games	114	202
	interactive stuff	44	
	virtual reality	26	
	social media	18	
MULTIMEDIA	videos	47	146
	multimedia presentations	14	
	kioks	14	
	holograms	47	
	films	14	
	computers	10	
EXPERIENCES	museum events	14	55
	making something new	36	
	guided tours	5	
INTERESTS	depends on their interests	40	40

TAKEAWAYS FROM STUDY #1

Results from this research study agrees with (Tzibazi, 2013) and highlights that teenagers do not see museums as appealing places. While teenagers have the perception that museums are good places for informal learning, these cultural heritage venues still remain unappealing to them.

Teenagers stated that games, interactive content, virtual reality, and social media were appealing methods of enhancing their visitor experience. Also, according to Falk (2009) the act of taking pictures to share a moment is an action from *Experience Seekers*, which is reflected by the fact that the teenagers talked about taking pictures and spreading the word to their friends about their experiences in a museum. This act of sharing pictures not only served as an advertisement but also created memories of the experience.

According to Falk, a visitor in a single tour could be more than one type of visitor. However, according to the results of the focus groups, I argue that, for a first interactive tour in a museum, teenagers could be seen as *experience seekers* as they wish to experience something new. Falk also argues that people who visit a museum with very particular and content-oriented interests fall into the category of *Professional/Hobbyists*. Some students felt to belong in this category by arguing that if the museums offered an exhibition that fit their interests, they would certainly visit it. However, this was a minor group of 40 expressions gathered, in comparison to the 403 expressions gathered about the use of *interaction* (202), *multimedia* (146), and taking part in *experiences* (55) inside museums.

STUDY #2: DEVELOPMENT OF GAMING MUSEUM EXPERIENCES THROUGH AN AUGMENTED REALITY TOOL

'Digital Natives' (Iversen & Smith, 2012b) and 'Gaming the Museum' (Dindler et al., 2010), museum experiences previous described in the *'State of the art'* chapter, do not incorporate teenagers as the developers of technology, but rather as designers of the technology. In the study 'Digital Natives' (Iversen & Smith, 2012b), the teens' ideas were presented to a team of interaction designers who would be responsible for integrating the voices of the participants into a prototype. Similarly, in the case study 'Gaming the Museum' (Dindler et al., 2010), the participants had not developed a technological prototype. For my second study, I conceptualized, designed and deployed a co-design activity for teenagers (aged 15-17), where teenagers together with me jointly created and designed medium-fidelity prototypes for two museums: the Medicine, and the Engineering Museums from the University of Porto. The participants were divided into groups and invited to think and create games and story plots for a selected museum. All the prototypes were made by the teenage participants with the support and guidance of the researcher and the HP Reveal software (known as Aurasma), an augmented reality tool.

This study reflects that participatory design methods can involve teenagers in the design process of technology for museums. It also shows that the teens' everyday engagement in relation to games is mediated through the adventure genre, and that in terms of engagement, giving teenagers the chance of realizing their own digital prototype can be of greater satisfaction than having others do it.

SAMPLE

I proposed a one-week activity plan [Appendix 1] to a summer camp in the Junior University of the Faculty of Engineering of the University of Porto. The activity, targeted at teens aged 15-17, consisted in developing gaming experiences for specific museums, and it was deployed during two weeks [Appendix 2]. The participants whose parents or guardians gave consent for participation in the study [Appendix 3], 13 in total, were divided into 5 groups. The first week had 2 groups (3 participants per group) who worked with the Engineering Museum, and the second had 3 groups (two groups of 2 participants and one group of 3 participants) who worked with the Medicine Museum.

PROCEDURE

The teenagers were involved in a series of game activities for one week, and two days were reserved for the design and deployment of the experience for the selected museum. The HP Reveal software (*Aurasma is now HP Reveal*) was one of the many easy and free tools out in the market that was chosen to be used within this activity. HP Reveal is an Augmented Reality (AR) site which allows us to see and interact with the world through auras. Auras are the digital content which will be unlocked by the HP Reveal app – auras can be as simple as a video and a link to a web page, or as complex as a live 3D animation. For the purpose of simplicity, I chose to make each aura as a video that the participants would create. Over two days, the following activities were organized:

1. *Introduction of the HP Reveal software.* Participants could unlock small videos with informative content in each exhibit of the museum. These auras should enhance the exhibits' scientific information, and participants would assemble the videos.

2. *First museum tour.* This tour was led by the museums' curators without any digital support. The participants were then invited to take pictures and notes from the exhibits they thought would best suit their interactive museum experiences through the HP Reveal software.

3. *Brainstorming in groups*. This was the time wherein participants were divided into groups and the concept of the experience was defined in relation to the first museum tur where they took pictures and notes regarding the exhibits that they found interesting. To prompt their imagination, they were required to brainstorm their experience as if it was an escape room (Nicholson, 2015), that is to say that they would have to create a story and riddles to solve within a time limit in order to successfully finish the experience. Participants were free to think of which storytelling plot suited best with the museum as well as which riddles to apply, bearing in mind that an aura would be just a video. Hence, the riddles should appear in the end of the video deployed to create one aura. These videos needed to include information about the exhibits within the story they created and give a clue to the other point of interest. The participants were the ones leading the ideas, while the researcher listened to them and also contributed to the reasoning of the ideas generated.

4. *Script construction I.* After defining the experience, participants started creating scripts for the videos at each point of interest. For each aura, they were required to write: (i) which location the aura is related to; (ii) if any image appears; (iii) which dialogues, if any; (iv) which clue will guide the player to the other point of interest (Figures 7-8). I had a more passive role – the participants led the script while I contributed to it with small details to be added to the text and improve readability.

5. *Second museum tour.* A second tour to the museum was made to clarify some doubts about specific exhibits or points of interest regarding each experience that was being developed.

6. *Script construction II.* Finalization of the script according to the changes made regarding the second tour (Fig. 9).

7. *Development of the videos.* With the script finished, the participants started making the video for each aura. The content of these videos was made by the teenage participants on their own. Some of them recorded theatrical performance while others recorded their voices and put together images. The videos and voices were recorded with an iPhone 6, and the manipulation of the video was made in the native video software of their computers (Windows Movie Maker).

8. *Converting videos to auras.* The videos were uploaded to the HP Reveal software through a computer. Here I had an active role in guiding and assisting the participants with the technology.

9. *Third museum tour.* This tour was finally made with the HP Reveal app. As said in the beginning, the aim of these experiences was to be compared to an escape room. For this, each group experienced the game of others while I was monitoring the time they took in order to check who would be the winning group.

10. *Evaluation from the participants.* To end with, all the participants filled out a survey concerning their thoughts about this experience of designing together for a museum tour (Table 3).

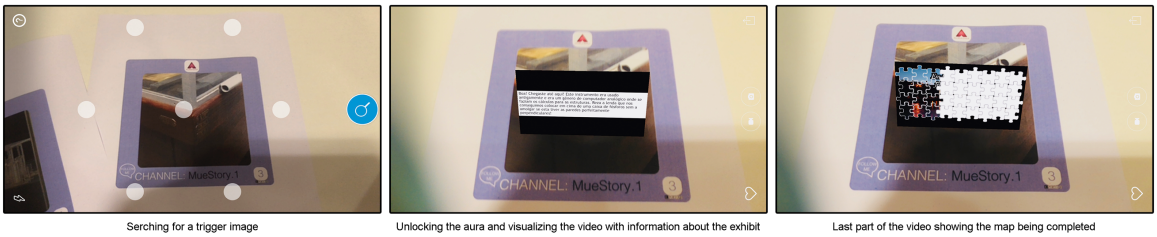


Figure 7. *Images of the interaction of the third moment from the Bridge Builder tour.*

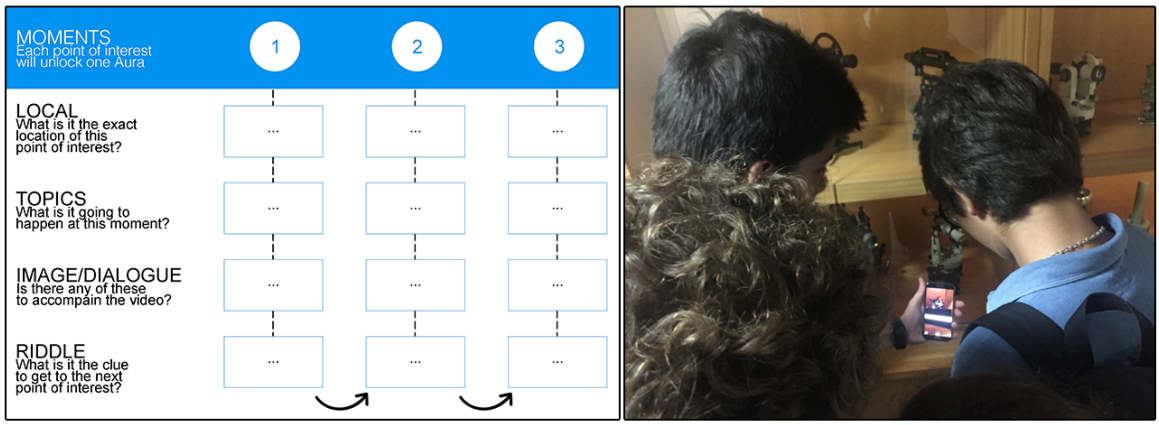


Figure 8. *On the left: Graph showed to the participants to help them to construct the script. On the right: One group taking the 'Bridge Builder' tour throughout the Engineering Museum, near the Topographer no. 21.*

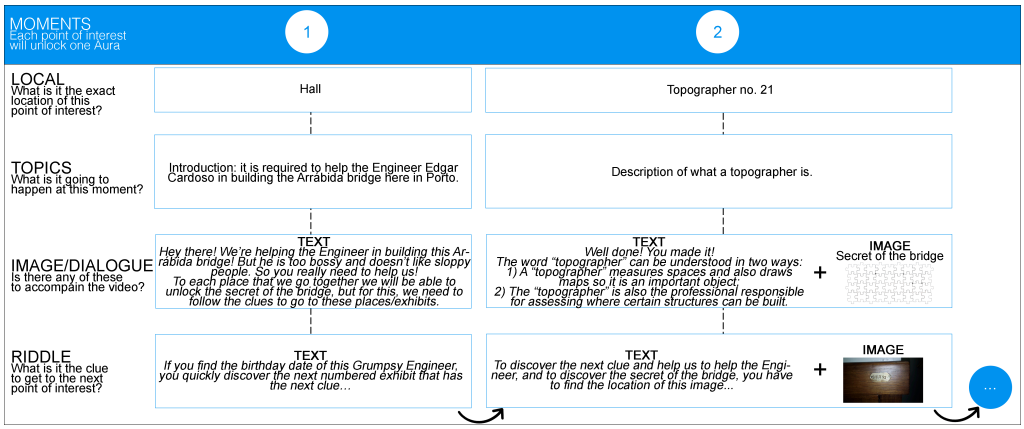


Figure 9. *Example of the first two moments of the Bridge Builder's script.*

Table 3. *Questions and measures adopted.*

Question	Measure	
Q1) What did you think about the FIRST TOUR to the museum led by its director?	Five degrees of happiness (L. Hall et al., 2016)	Teenagers were asked to rate, on a 5-point Likert scale, how much they enjoyed the event. Each smiley was then scored as: 1= awful, 2= not very good, 3= good, 4= really good, and 5= brilliant. [Appendix 4]
Q2) What did you think of the CO-DESIGN activity of a game for the MUSEUM?		
Q3) What did you think of the activity of EXPLORING THE MUSEUM with the GAMES that your colleagues developed?		
Q4) Do you think that you will use the HP Reveal application in the future?	Again-Again table (J. C. Read & MacFarlane, 2006)	In the table, users needed to select one of the following options: Yes, Maybe, No.
Q5) Describe all the activity you made for the MUSEUM in one sentence.	Writing	
Q6) On what occasions and for what reasons would you use the HP Reveal app?	Writing	

ANALYSIS

Below, each mobile tour is escribed in details into two subsections: (i) storytelling plots, (ii) game mechanics. The evaluation of the sessions was made through the average of the scales

applied on Q1, Q2, Q3 and Q4. The qualitative evaluation was the sum up of the results from Q5 and Q6.

RESULTS

This section described the videos[14] developed by the participants in terms of storytelling plots and game mechanics [Appendix 5].

STORYTELLING PLOTS

The teens created several storytelling plots that can be grouped into five types of stories (Table 4):

1) *Bridge Builder* [Appendix 6]. In this plot, throughout 5 points of interest, the player needs to help an Engineer to construct a bridge. At each point of interest reached, the player can unlock several pieces of the puzzle which will uncover the 'secret of the bridge'. This secret of the bridge is an image of a real bridge in their region coordinated by the engineer featured in the exhibition.

2) *The Final Landing* [Appendix 7]. This plot revolves around an astronaut that landed on earth and needs to construct a landing bridge to go to his planet again. In each point of interest (total of 6), the player will find the necessary tools to build the bridge and take off towards his planet.

3) *Help the Doctor* [Appendix 8]. In this plot, throughout 5 points of interest, the player needs to help a doctor, who it is in the middle of a surgery, to find a specific tool to complete the surgery.

4) *Medicine History* [Appendix 9]. In this plot, throughout 7 points of interest, the player gets to know relevant facts about the history of medicine narrated by a character presented in the museum.

5) *Visiting the Medicine Museum* [Appendix 10]. The story plot with 6 points of interest, tells the story of a person that would like to find a specific portrait in the museum and needs the help of the user to find it.

GAME MECHANICS

Teens created seven types of game mechanics (Table 2) all revolving around enigmas leading to the next exhibit to encounter:

[14] The videos scripts are accessible online in the following link: https://goo.gl/T2RTZ9

1) *Calculation* of a number that will lead to the number of the next exhibit;

2) An *image* of an exhibit that the player needs to find its location in the museum;

3) A *name* that the player needs to find to which exhibit it is related to;

4) A *metaphor* in which the players need to find understanding regarding the museum premises;

5) *Translation* that the players need to make, for example a sentence in other language, or a written phrase from back to front;

6) *Morse code*, each symbol represents either a text character letter or numeral and is represented by a unique sequence of dots and dashes;

7) *Binary code*, a coding system using the binary digits 0 and 1 to represent a letter.

Table 4. *Game mechanics used per experience.*

	Calculation	Image	Name	Metaphor	Translation	Morse code	Binary code
Bridge builder	x	x					
The final landing		x	x	x		x	
Help the doctor			x			x	
Medicine history		x	x	x	x		x
Visiting the museum	x			x		x	x

EVALUATION

In general, in regard to the results from Q4 and Q6 (Table 2), all the participants enjoyed the activity and most (12 out of 13) would use the HP Reveal application in the future in their school's assignments, or even to have fun with their friends. Regarding Q1, 11 participants out of 13 rated the first museum tour, led by the museums' curators, as 'really good', and the others as 'good'. Concerning Q2, 11 participants out of 13 rated the co-design sessions as 'brilliant', and 4 rated as 'really good'. The activity of exploring the museum with the experiences developed by them (Q3) was rated by 9 out of 13 as 'brilliant', and as 'really good' by 4 out of 13. In overall, the co-design session of a museum experience was referenced by the participants (Q5) as 'innovative', 'fun', 'interesting', 'different', and 'productive'.

TAKEAWAYS FROM STUDY #2

With this study, I contributed to the literature reporting on co-design with teenagers, thereby opening this area to further exploration (Read et al., 2013) by researchers, designers,

and even curators of museums. Adopting a 'cooperative inquiry' strategy, I situated the participants as the main subject throughout the entire design process of the sessions (Druin, 2002). Teenagers played an active role in the creation and development of ideas, while I played a more passive role by guiding their voices through the predetermined schedule for the sessions, as well as by evaluating the logic of their stories and of the game elements that teenagers proposed. According to other studies about participatory design sessions with teens in museums, such as 'Digital Natives' (Iversen & Smith, 2012b) and 'Gaming the Museum' (Dindler et al., 2010), teenagers become enthusiastic about, and enjoy participating in, activities in the museum that they have created through paper mock-ups, or technical prototypes developed by others. Similarly, our study indicates that, in terms of engagement, the ability to create their own digital prototype was more satisfying than having others do it. These teens visited the museum, took pictures, and created a narrative with game elements that they remembered or searched for on the Internet. Subsequently, they built videos using native video programs on their computers. This generation of teens is very fluent in the use of new technologies and experienced no significant difficulties in handling digital content.

In terms of the practical results of this work, teenagers thought about adventure themes to add to a story plot. In four groups out of five they embarked on a journey through the museum in search of something to help a greater cause (*Bridge builder, The final landing, Help the doctor, Visiting the medicine museum*). This highlights how teens' everyday engagement in relation to games can be mediated through the adventure genre and suggests that a digital interaction in the museum, directed to this audience, could contain these elements of adventure in order to capture their attention. Regarding game elements, participants thought of clues that led players through a treasure hunt. Clues ranged from basic ones, such as an image or a name of an exhibit, or even a metaphor describing how to get to these exhibits, to more complex ones, such as the need to translate a sentence from a foreign language or to use the internet to decipher a code. There was not one experience more successful than others. The clues, metaphors and story mysteries involved within these, triggered the participants the most in developing the experiences and experiencing the others. I conclude that teenagers, when invited to think about adding clues to the experience, come up with several clues that challenge the players. The more difficult and more challenging the clues are, the greater the involvement of the users becomes.

CONCLUDING SECTION: STUDIES #1-#2

In light of this set of research studies that sought to understand teenagers and their museum experience, I group the main conclusions into four topics: (i) how teenagers see museums, (ii) how teenagers feel about experiencing interaction in museums; (iii) engagement as a means of attracting teenagers to museums; and (iv) which methods should be considered when one is designing a museum experience targeted at teenagers.

The use of technology in museums could inspire teenagers to take a closer look and could create personal connections between the teenage visitor and the exhibition. Teenagers describe museums as powerhouses of informal learning. Nevertheless, these institutions remain unappealing to them.

Nowadays, teenagers are very fluent in the use of new technologies and do not have trouble handling digital content. This target audience is keen to experience digital interaction through new formats in a museum, such as by using mobile applications, and engaging in interaction through proximity.

The teens' everyday engagement with respect to interaction in museums is mediated by games and the adventure genre. Moreover, teenagers experience greater satisfaction in creating their own digital prototype for a museum rather than having others do it.

Games, interactive content, virtual reality, and social media seem to be appealing methods of enhancing their visitor experience. However, care should be taken when deploying such experiences as escape rooms and clues, as this might push teens through the exhibits too quickly and encourage them to finish the visit rather than enjoy it.

3.3. FRAMEWORK FOR CO-DESIGNING MOBILE MUSEUM EXPERIENCES

At this stage of the research, I position teenagers as designers of museum experiences for the Natural History Museum of Funchal (NHMF) through a framework that is intended to enable teen participation in the design of mobile interpretive exhibitions (Cesário et al., 2017). Hereinafter, I describe the framework and the three studies carried out with it, with a total of 155 teenagers. The data was analysed thematically according to three main topics: first, patterns that experience designers and curators could access to understand which design features an enjoyable museum experience for teenagers should have (study #3); second, an understanding of which kinds of narratives and mechanics the mobile museum experience could include to attract teenage visitors (study #4); and third, the teenagers' impression of the co-design process itself, and the proposed framework (study #5). I had not integrated the ideas of the participants from studies #1 to #2 into the subsequent studies as I wanted to check if another sample of teenagers would give similar or different insights from the ones of the previous studies.

THE FRAMEWORK

To fill the gap encountered in literature regarding active involvement of teenagers in the design of interactive technologies for museums, I adopted a user-driven innovation framework (Buur & Matthews, 2008) along with a cooperative inquiry approach that positions participants as 'design partners' (Druin, 1999), creating a co-design framework designed to involve young users in the ideation of mobile experiences for a local museum. Instead of immediately designing in response to the challenges that were pinpointed by our target audience in the previous studies, I rather harnessed their potential and ideas as valuable sources of information and inspiration to understand how mobile museum tours can be enhanced from a teenagers' perspective by understanding which mobile features would engage them while taking an interactive mobile museum tour.

THE METHOD

As the goal of this research was to engage teenage audiences in the design of interactive experiences for museums, I involved groups of teenagers to co-design together with me concepts for enjoyable mobile museum experiences. Teens were asked to fill and work on two

proposed sheets: 'Sheet A: concept sheet', and 'Sheet B: interface design sheet'. For this purpose, I engaged 155 teenage participants in a single session of multiple co-design short bursts, gathering teens' ideas about their values concerning engaging museum mobile tours. By working in groups, teenagers played an active role in the creation and development of ideas (acting as informants and sources of innovation). Through a cooperative inquiry approach (Druin, 1999), I had a rather passive role in guiding the participants' voices through the predetermined schedule for the session, as well as evaluating the logic of the concepts that teenagers proposed.

The data was extracted from pen and paper compiled sheets, where participant designed and expressed their preferences and ideas. The data was later analysed, looking for trends, and concept generation, according to Hakkila et al.'s methods (2016). I followed Druin's methods (2001) on how to work with young participants.

SAMPLE

After obtaining the necessary permission from the Regional Education Department [Appendix 11], I approached several schools to gather teachers interested in having their students taking part in this research study: as a consequence, teachers chose the classes of students willing to take part in it. I then had students from different schools, classes and regions of Portugal: two secondary schools in Funchal, students doing internships at the Interactive Technologies Institute (ITI/LARSyS) and students taking part of a summer camp at the University of Porto. In total, 155 participants aged 15-19 took part in the studies (Table 5).

Table 5. *Graph containing the sample of the participants split by age and gender.*

Age	Female	Male	Total
15 y	9	12	21
16 y	4	30	34
17 y	10	27	37
18 y	15	26	41
19 y	11	11	22
TOTAL	**49**	**106**	**155**

PROCEDURE

The sessions (total of 11 sessions with 4-5 groups per session, with 3-4 participants per each group) took place in their normal classrooms and took 90 minutes to complete. The following topics were addressed: (i) introduction, (ii) 45-min co-design session, (iii) evaluation of the session by the participants (word association).

INTRODUCTION TO THE SESSION

I introduced the goal of the session, which was to gauge teens' interests and ideas about enhancing museums offerings. The MNHF was then introduced through a series of photographs that detailed the museum's collection (mammals, geology and reptiles). Subsequently, 13-points of interest relating to the museum's exhibit of taxidermy marine animals were identified on a physical map of the museum (Fig. 10). Afterwards, I asked how the participants could think of interaction and user experience for museum settings. Here, techniques from the field of interaction design were explained, such as: (i) research and ideation, (ii) low-fidelity prototypes, (iii) usability feedback, (iv) high fidelity prototypes, followed by (v) development, and finally (vi) the user-testing. Our focus was directed toward the design of a mobile application and therefore windows, icons, menus and transitions/gestures were also highlighted as important elements when sketching a mobile app. At the very end, students were asked to think about how several technologies could play a relevant role when visiting the museum. For example, Near Field Communication (NFC), Radio Frequency Identification (RFID), Quick Response Code (QR Code), Augmented Reality (AR), Mobile Virtual Reality (MVR), and Proximity Beacons were provided as a set of examples of their usage (shown in the 'State of the Art' section). These technologies were explained in depth along with examples of their usage.

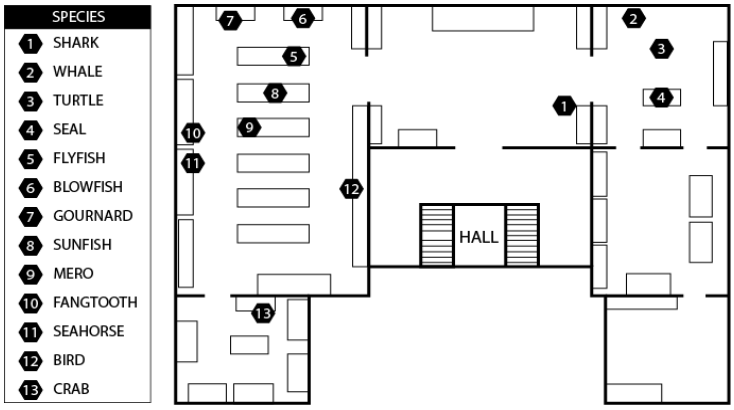


Figure 10. *The map of the rooms from the Natural History Museum of Funchal.*

CO-DESIGN SESSION

Finally, the 155 participants were divided into 46 groups, given two different working sheets per group (Sheet A and Sheet B), and then involved in a 45-minute co-design session (Fig. 11).

Sheet A: Concept sheet. It was meant to capture the overall concept for the experience, containing three text slots that could be used to explain the experience which they would like

to design and portray, helping users to write about their personal opinion and feelings, promoting critical thinking among them. Students were guided by the following probing questions:

1)Narrative: what is the narrative underlying the experience?

2)Species/Exhibits: how do visitors interact with the museum's exhibits?

3)Mechanics/Tutorial: which steps do users have to take to complete the experience?

Sheet B: Interface design sheet. It contained an empty wireframe that could be used to draw the interface details for the mobile application that our participants had previously described on Sheet A.

When the groups were settled (Fig. 12), they were advised to brainstorm encouraging the 'feeling that everything was possible' (Druin et al., 2001), and asked to think in terms of mobile interactive experiences they would enjoy.

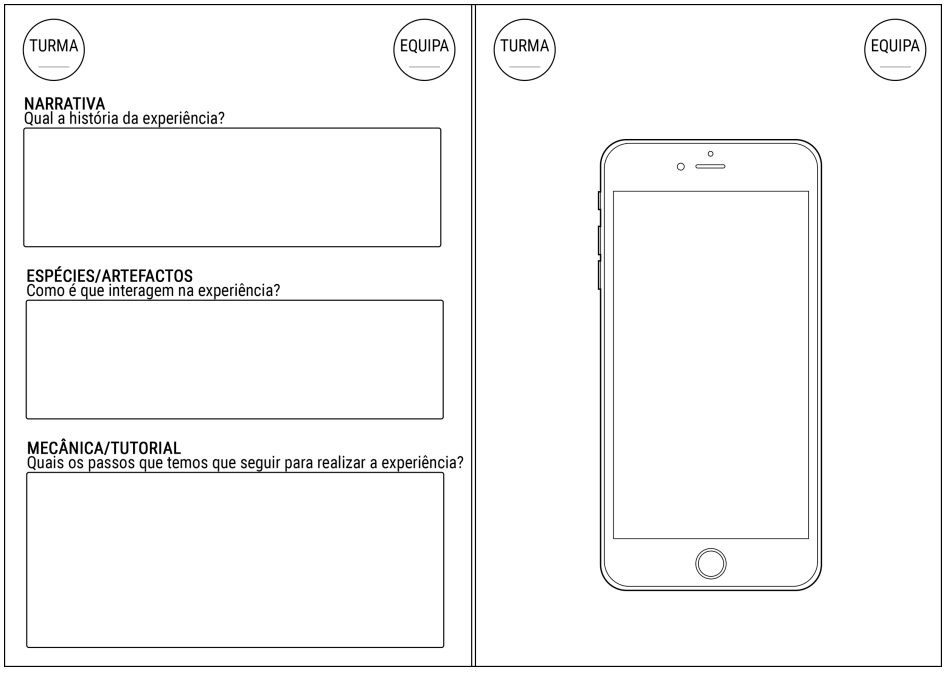


Figure 11. *Sheet A: concept sheet (left), and Sheet B: interface design sheet (right).*

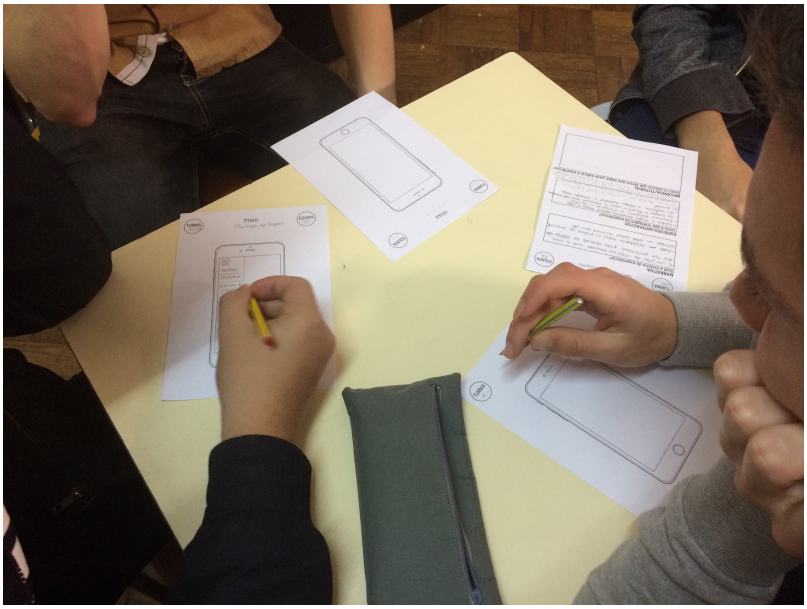


Figure 12. *A group discussing their ideas.*

Evaluation

At the end of the 45 minutes of co-design activity, the participants were invited to describe the co-design session in one word on a piece of paper, which would remain anonymous, in order to rapidly identify their feedback on the co-design session carried.

Analysis

The data was analysed according three different topics: (i) design patterns, (ii) ideas for mobile museum experiences, and (iii) engagement of teenagers with the co-design process. The data analysis is described in the next sections.

Design patterns

When analysing the data collected, I focused on what teens intended to add as must-have features to the natural history museum tour. To this end, I transcribed all the words on *Sheet A* and all the drawings on *Sheet B*, and counted how many times each feature appeared. Then, through Thematic Analysis I coded these features to understand patterns of features that an engaging museum experience should have to appeal to teenagers, such as which gaming elements, which kind of interactions with the exhibits, which roles social media takes, and, which kind of information about the museum story they would be keen to check.

Game mechanics and narrative plots

For this analysis, I focused just on the results of *Sheet A: concept sheet*. A summary of each sheet gathered was prepared by me, and then through Thematic Analysis these summaries

were categorized. This analysis focused then on the teenagers' creation of concepts related to their interests regarding enjoyable mobile museum experiences: gamification and storytelling plots.

ENGAGEMENT ON THE SESSIONS

An analysis of how teen participants responded to the design session was conducted using Thematic Analysis to show the different categories of adjectives used by participants in their evaluations. The goal for the evaluation was mainly to pilot the design session process and if teens enjoyed participating in it.

STUDY #3: DESIGN PATTERNS

This study is centred around the thematic analysis applied to the results gathered from the words on *Sheet A* and all the drawing on *Sheet B*, as well as reporting the challenges I faced with the analysis and attempts to overcome them. I chose to highlight the set of words and drawings rather than analyse the ideas that were generated in the co-design sessions because at this stage the goal was to generate patterns to understand which design features our participants envisaged for compelling museum experiences. The analysis of the results highlights a handful of must-have features on (i) gaming, (ii) interactions, (iii) social media and (iv) museum-related aspects that an engaging museum experience for teenagers could cover.

ANALYSIS

I used Thematic Analysis to analyse the data gathered. This technique is used for identifying, analysing, and reporting patterns within data. It organises and describes the data set in detail (Braun & Clarke, 2006). NVivo 11 was used to organise the analysis. A detailed analysis of sheets A and B was conducted.

Sheet A: The following steps were taken:

1) *Familiarizing ourselves with the data:* I firstly started coding the results from sheets A. The phrases that each group wrote on sheet A were transcribed (I refer to them as transcripts, where each sentence element stands as one transcript)
2) *Generating initial codes:* Then these transcripts were categorised into codes that had the same meaning, highlighting patterns and trends emerging from participants' transcripts.
3) *Searching for and reviewing themes:* These codes were then grouped into subthemes, and finally, the codes were sorted according to overreaching themes (Fig. 13). I organised the data into 4 main themes that will be shown on the next section. The relation between codes and themes was triple checked by the me to guarantee the same meaning.
4) *Defining and naming themes:* Themes were refined to identify broad themes and subthemes, and given clear names and definitions to capture the essence of each one. A thematic map with codes, subthemes and themes was generated from this step (Fig. 14).

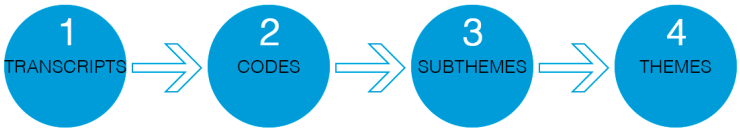


Figure 13. *Map of how the thematic analysis was conducted.*

Sheet B: The challenge with sheet B was how to code the drawings. To overcome this challenge, I transcribed all the graphic elements as short description (transcripts), and then, categorised them into the codes derived from sheets A, and consequently, subthemes and themes. The captions near the buttons helped us to understand which interaction the button would have (Fig. 15). For example, some participants wanted a ranking button. Some of them drew a button typing ranking on it, while others drew a square and then made a caption informing us that by typing this button the user will check the ranking. For both of these examples, I coded the buttons as 'ranking'.

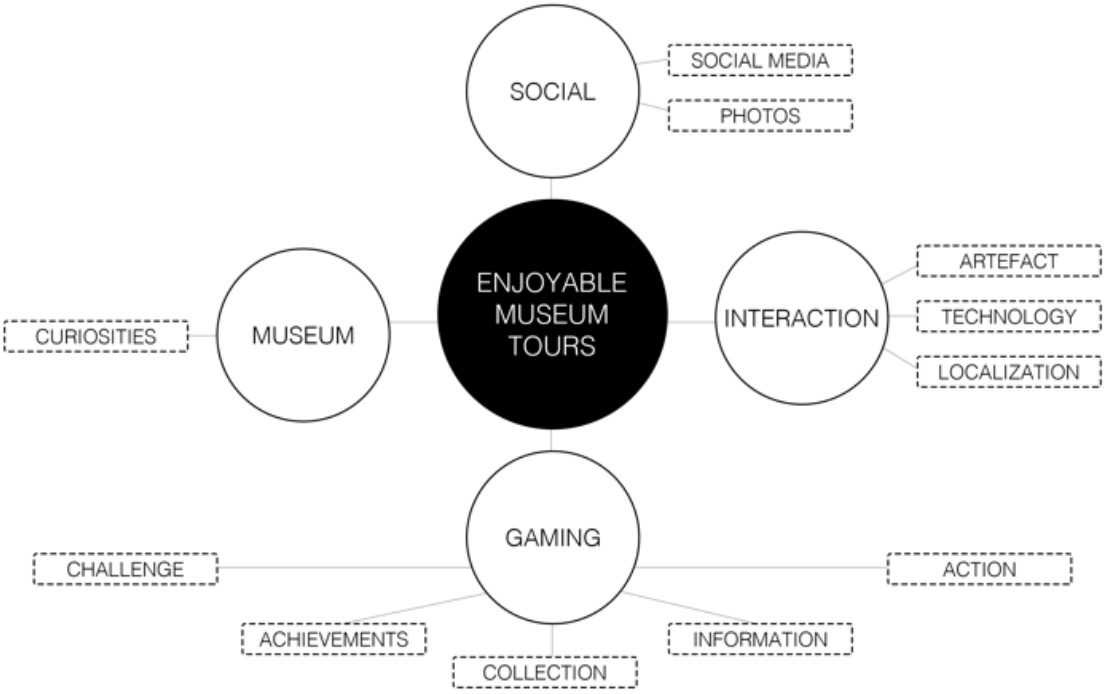


Figure 14. *Map derived from the qualitative analysis.*

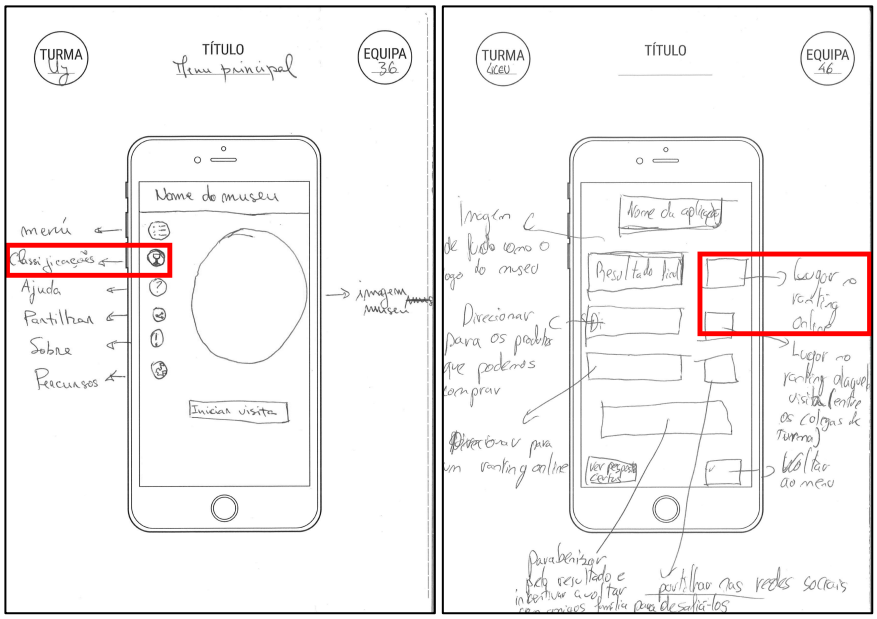


Figure 15. *Examples of design sketches containing a 'ranking' button. Left: the participants drew a circle with a person, then they caption it as 'ranking'. Right: the participants drew a square and caption it as 'place in the online ranking'.*

RESULTS: NOTES TAKEN DURING THE CO-DESIGN SESSIONS

During the co-design sessions, several issues were raised by our participants. Firstly, students advocated for a greater use of interactive technologies in museums, some argued specifically for the importance of play and enjoyment while others suggested a combination of both technology and enjoyment. One group in particular, stressed the value of simplicity and usability to appeal to a wider audience. As teenagers were progressing with the co-design sessions, I also took note of some of their spontaneous remarks which highlighted feelings of excitement towards the technological interventions that they were ideating: *"This is fun!"*; "*This is better than Pokemon Go!"* and "*For sure I would go to the museum just to try something different like this"*.

RESULTS: DESIGN CATEGORIES

From coding sheets A and B, I got 805 individual transcripts which reflect patterns and trends of teenagers regarding enjoyable museum experiences (Figures 15-19). Those transcripts were grouped into 42 codes, then categorised into 11 subthemes, and finally categorised into 4 main themes, namely (i) *Gaming* (361 transcripts), (ii) *Interaction* (381 transcripts), (ii) *Social* (39 transcripts), and (iv) *Museum* (24 transcripts).

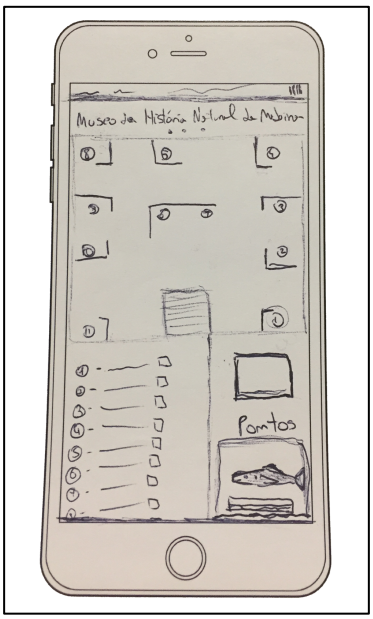


Figure 16. *Interface sketch from Group #10. They sketched some points of interest in a map, and punctuation (Themes: Interaction, Gaming; Subthemes: Localization, Achievements; Codes: map, location, points).*

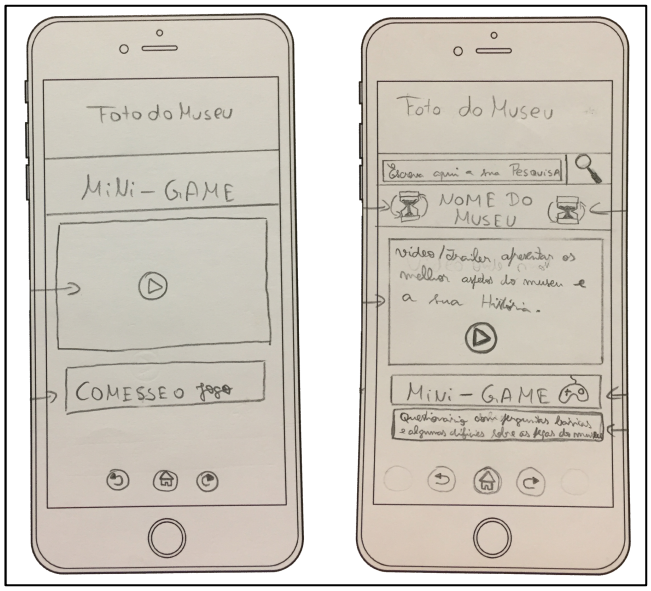


Figure 17. *Interface sketch from Group #8. From left to right: 1) the first screen of the app depicts an introduction to the game through a playable video (Theme: Gaming; Subtheme: Information, Challenge; Codes: tutorial, game); 2) the second screen shows a video about information of the museum, and buttons to start a mini-game (Themes: Gaming, Museum; Subthemes: Challenge, Curiosities; Codes: game, museum).*

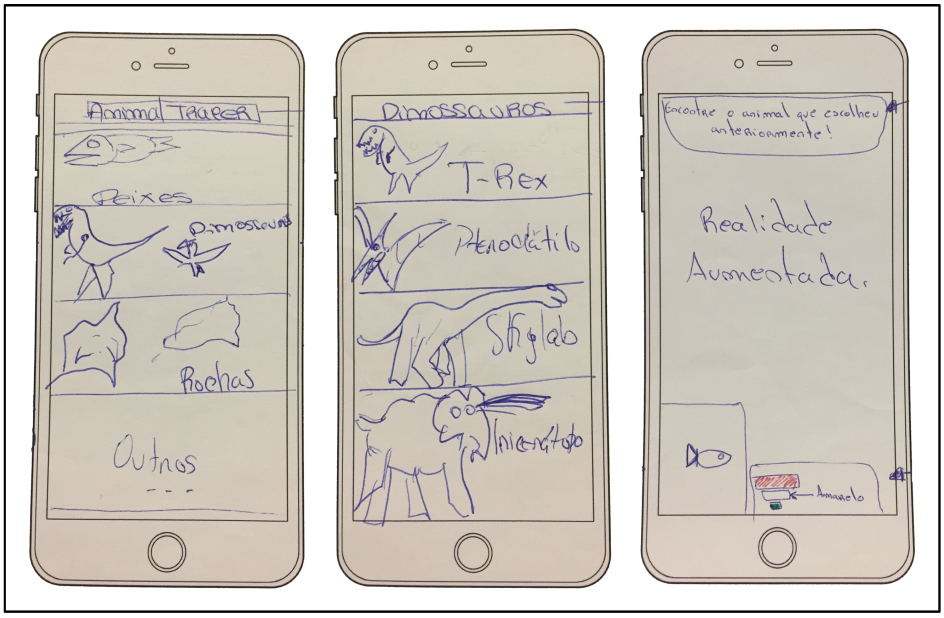


Figure 18. *Interface sketch from Group #20. They sketched 1) a list of categories of the main exhibits (Theme: Interaction; Subtheme: Exhibit; Code: categories and choosing); 2) a list of detailed species of a category chosen (Theme: Interaction; Subtheme: Exhibit; Code: categories and choosing); and 3) augmented reality to find the specie selected (Theme: Interaction; Subtheme: Technology; Code: augmented reality).*

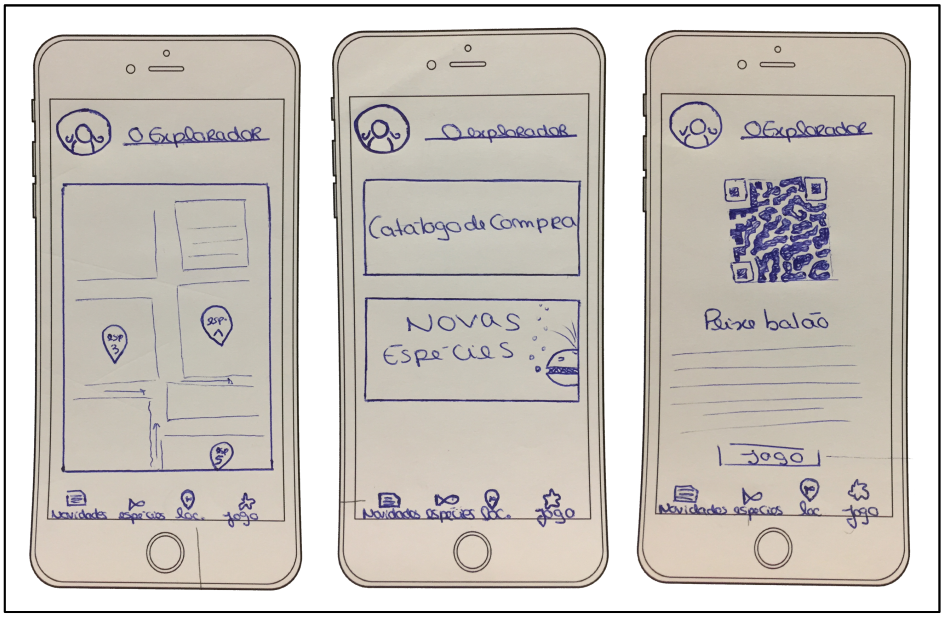


Figure 19 . *Interface sketch from Group #29. They sketched 1) the map of the museum highlighting points of interest (Theme: **Interaction**; Subtheme**: Localization;** codes: map, location); 2) a list of categories to choose (**Theme**: Interaction; **Subtheme:** Exhibit; **Code**: categories and choosing); and 3) the information revealed through a QR code (**Theme**: Interaction; **Subtheme**: Exhibit, Technology; **Code**: information, QR codes).*

GAMING

All groups made use of some game element in their concepts (Table 6). Participants would enjoy the implementation of challenges within a museum experience to prompt them to search and discover exhibits and be provided with more information about these. This idea is based on solving riddles/enigmas to deepen the experience. The resolution of the riddle will prompt the user to go to another specific exhibit and receive information about it as well as another riddle/clue, and so on. These challenges could come through quizzes and mini-games as well. The implementation of a timer and a ranking would also challenge these visitors when performing the mobile experience in order to have a better performance at the end of it. Additionally, it is important to give feedback to users about their progression within the experience. The fact of receiving points, unlocking information and increasing the level of the game are examples of achievements that could challenge the player to discover museums.

Moreover, the concept of collecting pieces to form a bigger picture, or completing a puzzle, was also referred by the participants. Finally, as any game, participants suggested having the power to request some information within the app, as well as a tutorial at the beginning. Also, they would like to have some action as buying items during the game experience and having the power of feeding some characters or species in an experience.

Table 6. *Subthemes assigned to the 'Gaming' theme accompanied by their codes, frequencies, and examples of their allocated transcripts.*

Theme: GAMING			
Subtheme	**Codes**	**Freq.**	**Example of transcripts**
Challenge	Clues: to follow a challenge	37	• *Look for the animal though clues* • *The specie unlocks multiple clues for the next specie* • *We must follow the clues given to us*
	Riddles: to follow a challenge	18	• *We will find parts of the story and in then we must join them and understand what happened* • *List of riddles to be uncovered* • *The user starts by the first point and the first puzzle is revealed*
	Quiz: to challenge the knowledge	57	• *Fill a questionnaire* • *Answer to basic questionnaires* • *The specie asks you questions*
	Timer: to challenge the tour	4	• *Limit number of lives and time* • *At the end of 12 minutes one loses one life* • *The time will be counted and will be used as a penalty*
	Game: to play	24	• *Start the game* • *It's a game about the museum's artefacts, such as curiosities about the* • *It's a journey through a game*
	Ranking: to check status	23	• *In the end, there is a ranking of the time done* • *You can check your position in the raking during the museum tour* • *In the end, a table will be displayed with the final results*
	Progression: to check the game progression	8	• *Watch the progress of the game* • *Bar of right answers* • *Level bar*
Achievements	Achievements: to win	59	• *Winning awards* • *To get the surprise prize* • *In the end, you receive an award*
	Points: to get points in game	30	• *We earn point by getting the questions right* • *If we win, we get extra points* • *At the end, we have the final score*
	Unlock: to challenge	16	• *Unlock the next challenge* • *One part of the map is unlocked* • *The code unlocks information*
	Treasure-hunt: to find a treasure	12	• *Treasure-hunt in the museum* • *There's a treasure in the museum and you have to find it* • *This is a treasure hunt!*
	Levels: to progress	8	• *Whenever you "pick up" certain species you go up on the level* • *Move to the next phase* • *The questions will have different levels of difficulty*
Collection	Collect: exhibits and stories	22	• *We have a button to see the animals discovered* • *List of the many symbols that we collected* • *We can save all the answers gathered for at the end to uncover a story and understand the experience*
	Complete: the whole experience	19	• *We must complete all the steps, leaving none to be done* • *Complete all the levels* • *There's a puzzle in each museum's specie and each piece places correctly displays new information*
Information	Help: to help and be helped	13	• *You will receive help from various species* • *You have to help the animals that are trapped* • *Find an animal, understand the problem and help*
	Tutorial: to understand the experience	5	• *Follow the instructions* • *Application description* • *Video tutorial*
Action	Shop: to buy	4	• *We can buy food to feed the virtual animal* • *Buy an animal* • *Buy the first species with money in game*
	Feed: to make it grown	2	• *Digitally feed the animal and make it grown* • *Feed the animal*

INTERACTION

The theme of *Interaction* recalls the desire of the participants to have some interaction with exhibits inside the museum (Table 7). Firstly, this kind of interaction could happen by receiving information about the exhibits in several ways, such as text, sound, video or image. Users expressed the desire of having a set of options in the mobile app to choose from, and

consequently choose which kind of experience they would like to take. Likewise, they would like to interact with images, especially with 3D models of the exhibits. Additionally, also taking the role of an exhibit, where they could visit the museum through the eyes of a selected species. This kind of interaction could also happen through the technology used to unlock content. Moreover, another form of interaction within the mobile app is having feedback on the location of the exhibits that should be encountered.

Table 7. *Subthemes assigned to the 'Interaction' theme accompanied by their codes, frequencies, and examples of their allocated transcripts.*

Theme: INTERACTION			
Subtheme	**Codes**	**Freq.**	**Example of transcripts**
Exhibit	Information to know the exhibits: textual, sound, video, image	98	• *It will appear a little bit of sound information about the animal* • *When we find it, it shows all the information about the specie* • *It shows a picture of the exhibit*
	Categories and choosing: to choose form different tours	41	• *Choose a specie to start the tour throughout the museum* • *Choose the animal you want to search for* • *People can choose the category they prefer*
	Interactions: to interact with the exhibit	16	• *We can move the species in the app* • *Rotate the picture of the animal* • *Interact with the species*
	User takes the role of an exhibit: to have a different role	11	• *The user stands in the place of the fish and navigates through the museum* • *We choose the specie we want to control* • *We experience the life and a regular day of one of the species*
	3D object: to see the exhibits	6	• *When you hit the answer, you will see an entire animated 3D model* • *View the chosen animal in 3D* • *3D effect of the species found*
Technology	Augmented Reality: to see the exhibits	25	• *In the app, there's a camera that allows you to view images that are not in the museum* • *Open the camera view to see the fish* • *Species will appear in augmented reality in the application*
	Beacons: to unlock content	22	• *Each specie has a beacon in which a question appears* • *We must pass the mobile phone on the beacon to carry out the activity* • *When we pass near the beacon we see some information*
	QR codes: to unlock content	17	• *There's a QR code on each exhibitor to discover* • *When entering the museum, a QR code is available to download the application* • *To interact with the species, we have a QR code*
	Catch codes: to unlock content	14	• *Each specie has a sticker that is how will make them appear in the app* • *We should pick up the phone and go to the animal to see more* • *We must find the different codes that are spread throughout the museum*
	Virtual Reality: to see VR images	11	• *We see virtual reality glasses* • *We will have a VR glasses in each specie* • *A video about the animal appears in VR*
	Image recognition: to unlock content	4	• *The image automatically searches for the symbol in a list of symbols* • *Point the camera at the object and the animal appears* • *We need to focus on species and then will appear options to interact with*
	Gestures: to have a gesture for an action	4	• *Throw the fishing road and the animal appears* • *When making the fishing gesture appear clues* • *By the gesture of fishing we can see the animal in its habitat*
	Observe holograms	3	• *Interact with species through kiosks with access to the smartphone as a way of observing holograms* • *Holographic kiosks* • *Hologram as 3D effect of the species*
Localization	Search: to search exhibits	62	• *Walking to search the animals* • *We should look for species* • *Keywords search*
	Map: to check points of interest	22	• *Open the "map"* • *Map of the museum* • *The user has a map with various points of interests*
	Location: to check locations	18	• *When locating an animal, we should go towards its showcase* • *We know where we are* • *Location of species*
	Orientation: to guide the visitor	7	• *When we are close to the objective, we receive sound or textual signals* • *Whenever you get closer, as the person walks, it will appear on the mobile phone* • *Sound and visual signals to guide us*

SOCIAL

The *Social* theme highlights the desire of teenagers of sharing their experiences on social media channels within a mobile application as well as taking photographs (Table 8). This theme embraced the words and drawings regarding the usage of social media within the application, and taking pictures and selfies to have something to remember about the museum.

Table 8. *Subthemes assigned to the 'Social' theme accompanied by their codes, frequencies, and examples of their allocated transcripts.*

Theme: SOCIAL			
Subtheme	**Codes**	**Freq.**	**Example of transcripts**
Social Media	Social networks: to share	18	• *Share on social networks* • *Sharing experience in social networks* • *Login with your social network within the application*
	Profile: to have a profile	7	• *Build a profile* • *Avatar with our photo* • *Player profile*
	Friends: to have a group of friends	2	• *Create a group of friends who wants to participate* • *List of friends who are participating in the museum experience*
	See what others have done: to check other people	2	• *Online score from other people who have already been there* • *Pictures of other players*
Photos	Take normal photos	6	• *You can also take a photo of the animal* • *Option to take photos during the visit* • *Option to create a photo album*
	Take photos and selfies with AR	4	• *Selfies/photos with the animals in augment reality* • *Take a picture with augmented reality* • *Photo with the animal with his background in augmented reality*

MUSEUM

The *Museum* theme concerns curiosities about the museum (Table 9). These aspects concerns showing general videos and information about the institution.

Table 9. *Subthemes assigned to the 'Museum' theme accompanied by their codes, frequencies, and examples of their allocated transcripts.*

Theme: MUSEUM			
Subtheme	**Code**	**Freq.**	**Example of transcripts**
Curiosities	Museum: to have more information about the museum	24	• *Video about the best aspects of the museum* • *Images of the museum at the beginning* • *Medal with the museum logo*

TAKEAWAYS FROM STUDY #3

From this study, teenagers emerged as very keen to add game elements to their mobile museum tours. The emergence of game elements indicates the participants' desire to have a game-filled experience inside the museum. The participants showed an interest in having guidance through a tutorial at the beginning, to follow a challenge and test their knowledge, and to get points and progress within the mobile experience. Additionally, they sought to collect and make sense of exhibits and stories behind them, which was mandatory for completing the whole experience. This set of teenagers also showed interest in providing help

to the species in some way and in buying elements for making the species collected grow. Several research studies have also made use of game elements to engage children (Cabrera et al., 2005; Nilsson, Blackwell, et al., 2016; Xhembulla et al., 2014).

Exhibits play an important role in virtual interaction throughout the mobile museum experience. This interaction could take place in the form of giving information to the user not only through visual text but also through videos and 3D models, through which visitors can see specific details about the exhibit that is locked behind a pane of glass.

Teenagers are technology-oriented. After having access to mobile applications inside museums at the beginning of the co-design session, they thought of some technologies (AR, beacons, QR codes, and image recognition) for unlocking digital content in their concepts of mobile experiences. They were keen on checking content in AR and VR formats. Hence, they are interested in discovering the museums' exhibits through technology. Even if they are not familiar with the technology, they are excited to try it out. They enjoy searching for things and being immersed in a treasure hunt. Moreover, teenagers are interested in taking different tours through which they can interact with various exhibits on separate visits.

Teenagers are socially-oriented. They enjoy sharing memories of their experiences through their online communities, like the *Experience-Seeking* visitors from Falk's taxonomy of visitor experience (Falk, 2009). The memories that teenagers value could be in the form of pictures and selfies with AR features. On top of this, teenagers are eager to see what others have done by checking photos and global ranking scores.

Besides the addition of the game and interaction features to a mobile tour, teenagers also suggested providing more information about the museum building. This information could be presented through an introductory video that tells the story behind the building, to contextualise the goals for the teenage visitor, and also through images of the building's interior, to provide context about its premises.

The contribution of this analysis is that it highlights a handful of identified must-have features with respect to gaming, interactions, social media, and museum-related aspects that a museum experience could have for teenagers to consider it engaging. However, these features should be applied to a real-life scenario in order to validate its veracity on enjoyable museum experiences targeted at teenagers.

STUDY #4: GAME MECHANICS AND NARRATIVE PLOTS

In this study, I chose to highlight the ideas that were generated in the co-design sessions through the *Sheet A: Concept Sheet*. Through qualitative analysis, our findings suggest that teenagers value gamification and storytelling when thinking about enjoyable museum tours.

ANALYSIS

I used Thematic Analysis (Braun & Clarke, 2006) and NVivo to report the data gathered. A detailed analysis of *Sheets A* was conducted to extract the ideas of the groups. Each working sheet was transcribed and read by me multiple times. Then each sheet was summarised in regards to which features the museum experience should have. Teenagers' concepts could be divided into two main branches, such as (i) *game mechanics* and (ii) *plot models*. Then, for each of these two branches, each sheet was grouped into preliminary codes that had the same meaning (check Tables 10 and 11). A thematic map with codes, subthemes and themes was generated from this step (Table 12).

RESULTS

GAME MECHANICS

Each of the 46 groups was coded a single time into the *mechanics* branch, where we can check which mechanics emerged during the concept process. Into this branch, I found 8 different codes: (i) *catch & discover*, (ii) *challenge*, (iii) *puzzle*, (iv) *clues & riddle*, (v) *clues & quiz*, (vi) *clues as shadows*, (vii) *take control over a specie*, and (viii) *timer*. The description of each code and the frequency it appeared among the 46 groups can be checked at Table 10.

Table 10. *Description of the mechanics generated by the participants.*

CODES	DESCRIPTION	frequency
Catch & discover	Search and discover exhibits in the museum premises and provide information about them.	11
Challenge	A quiz or a mini-game about the exhibits where users will get points for the right answers and consequently some kind of reward.	11
Puzzle	Challenge the users to unlock/discover the fundamental pieces to complete the puzzle/collection and understand the puzzle as a whole.	7
Clues & Riddles	Solve riddles/enigmas to go further in the experience. The resolution of the riddle will prompt the user to go to another specific exhibit and receive information about it and another riddle, and so on.	4
Clues & Quiz	Visitors are delivered clues to find specific exhibits and then to answer a quiz.	4
Clues as shadows	Visitors are given a shadow of a specific exhibit as a clue, and they need to go throughout the museum to discover which exhibit that shadow belongs to.	4
Take control of a specie	The visitor plays the role of a specie in the museum. When visitors tour the museum, they do so through the eyes of a specific species of the museum.	4
Timer	There is a limit of 5 lives and one-hour time to complete the game tour. At the end of 12 minutes, one loses one life.	1

PLOT MODELS

After the analysis of the ideas, I was able to verify that 9 groups out of 46 groups, were very engaged in thinking narratively, creating adventurous and exciting plots to guide the audience through the museum. I grouped the narratives of these 9 groups into 6 codes: (i) *helping friends*, (ii) *pirate*, (iii) *explorer*, (iv) *aquarium*, (v) *chronologic trip*, and (vi) *fisherman*. The type of narrative plots and the frequency they appeared can be verified at Table 11.

Table 11. *Description of the narratives generated by the participants.*

CODES	DESCRIPTION	FREQUENCY
Helping friends	1) One of the museum's dangerous animals came to life and ran away, and only the visitors can find it. Throughout the tour, the visitors will receive advice from various animals that will help them complete their mission. 2) The turtle is in a plastic bag, and the visitors must save her. To save it they have to ask for help to the Crab that will help the turtle with its tweezers. Each animal is necessary to save some other animal, and so on.	2
Pirate	1) The visitor is a pirate who steals species with the goal of attaining a treasure; this treasure varies in the quantity and rarity of the species. 2) The visitor is a relic hunter with a special scanner that allows him/her to find hidden treasures disseminated in the museums premises.	2
Explorer	The explorer has to find the location of a secret message. The visitor needs to get in touch with several ecosystems, and will accompany the explorer in his search.	2
Aquarium	There is a virtual aquarium where visitors can create and take care of the species that are in the museum or that are endemic in the region.	1
Chronologic trip	This is a chronological journey through a set of tracks where the goal is to see who is the first to complete the trip. The visitor has the option of creating an album with photos of the animal. Visitors have the option to choose different routes depending on the category of the species.	1
Fisherman	The visitor can fish the animals through augmented reality. The visitor needs to make the gesture of fishing (with the smartphone) and it appears a clue saying where the animal that needs to be fished is. When the visitor finds it, they need to launch the fishing rod and the animal appears on the screen in its natural habitat where it is possible to interact with it.	1

THEMES AND SUBTHEMES

In the rest of this section, I will describe the main themes and subthemes that emerged from this study. I have grouped these findings into two main themes, (i) *gamification*, and (ii) *storytelling* (Table 12). Each theme is divided into several subthemes.

Table 12. *Thematic map with codes, subthemes and themes.*

1) BRANCHES	2) CODES	3) SUBTHEMES	4) THEMES
Mechanics	Clues & riddles Clues & quiz Clues as shadows	Clues	GAMIFICATION
	Catch & discover	Treasure Hunt	
	Challenge	Quiz	
	Puzzle	Collection	
	Take control	Simulation	
	Timer	Timeout strategy	
Narratives	Pirate Explorer Chronologic trip Fisherman	Adventure	STORYTELLING
	Helping friends Aquarium	Emotion	

GAMIFICATION

All 46 groups made use of some game elements in their concepts. From these 46 ideas, I extracted 6 possible game mechanics to captivate teenage visitors on taking a mobile museum tour; they are the following: (i) *clues*, (ii) *treasure hunt*, (iii) *quiz*, (iv) *collection*, (v) *simulation*, and (vi) *timeout strategy*.

CLUES

Within this subtheme, 12 groups out of 46 (total of 44 teenagers out of 155) made use of *clues* in their ideas. The *clues* may be combined with puzzles and with questionnaires. Eight of these groups referred to the *clues* in text format, the 4 other groups referred to the *clues* in the format of images, in particular, in the shadows format of the animals that they had to find out to unlock information. Moreover, these shadows are linked to enigmas because users have to discover which animal in the museum has that shape to continue in the game.

TREASURE HUNT

Teens have a strong appreciation of search and discovery activities. 11 groups out of 46 (total of 37 teenagers out of 155) involved *treasure hunt* elements in their design of their favourite experience at the museum. The *treasure hunt* is rooted in the tradition of rescuing something of value, relying on the desire of adventure and easy wealth. Often science and

entertainment are combined to rescue the past. However, the real treasure of the *treasure hunt* in the museum still would be the acquired knowledge. The *treasure hunt* determines the experience state, leads to rewards and represents achievements.

Quiz

In this category, I grouped the ideas of 11 groups out of 46 (total of 36 teenagers out of 155) about the use of *quizzes* in the design of their ideal mobile museum tour. This is not a novel technique, in fact, this is what is done in some museums with the teacher's support within a formal education framework. Students go on a school field trip and are invited to explore the museum and see some specific species (that they are studying) and in the end, have to answer some *quiz* regarding what they have seen or learned. What is interesting to note is that teenagers when asked about their preferred way to experience a museum still mentioned *quizzes* and tests about the knowledge gained in the tour. Is this result just the fruit of habit where participants are required to perform after a school field trip, or is it part of something they would truly enjoy measuring? Further studies could shed light on this issue.

Collection

The concept of *collecting* pieces to form a set or collection, a bigger picture or puzzle, is a widely used technique in gamification. The use of puzzle's solving among teens' designs was popular, 7 groups out of 46 (24 teens out of 155) made use of this technique as a favourite mean of exploring the museum *collection*. This concept, as it is defined (Belk, 1995; Farina et al., 2006), places the collector at a higher level than a simple consumer who intends to buy a product, since it gives it a higher added value. In addition to purchasing, using/consuming only once, *collecting*, instead, create a rewarding emotional involvement loop.

Simulation

This *simulation* is intended as the user simulating the behaviour and shape of one of the animals or exhibits showcased inside the museum and seeing the exhibition from its eyes. Only 4 groups of the 46 highlighted this technique as an engaging one to spice up the museum visit (total of 12 participants). Users can for example, choose a different taxidermy animal at different times, and each different animal would guide the visitor through different places and consequently would show and tell different stories. Each animal could have different characteristics, for example, if users choose to be a Hammerhead Shark, they would, in the digital context, have a 360º vision and therefore all the visit made by them in the museum would be enhanced by 360º vision. In turn, the shark being a big animal would scare the smaller

fish who would hide themselves from users visiting the museum as a shark. On the contrary, if users choose to be a smaller fish, this one would have a smaller field of vision and could be hiding from larger fishes, but connecting to a different ecosystem altogether.

TIMEOUT STRATEGY

The *timeout strategy* was used by 1 group (total of 2 participants out of 155). This approach consists in users having a certain time and number of lives to visit the museum otherwise their visit will *timeout*, and the story will end or the game lost. This study highlights the addition of challenges as strategies to be deployed on a mobile museum tour. The *timeout strategy* makes visitors want to be the best at their tasks and address what is needed quickly in order to not lose the game, which invites competition and fast viewing of the exhibition.

STORYTELLING PLOTS

From the 46 groups covered (155 participants), only 9 of them were thinking about narrative formats (total of 26 participants). These groups manufactured 9 different storytelling scenarios for a museum experience. From these 9 scenarios, I extracted 2 main possible guiding lines relating to storytelling plots to captivate teenagers' attention in museums; they are (i) *adventures*, and (ii) *emotions*. These scenarios may have a fictitious or simply imaginary basis as long as the focus is not only to find out more about the story but includes the use of the exhibits of the museum as a way to unravel more about the story.

ADVENTURE

Six out of 9 groups used *adventure* as a calling theme in their design (total of 18 participants). For the *adventurous* subtheme, teenagers tend to prefer a leading role for themselves. Examples ranged from being a nasty pirate or a well-intentioned explorer walking around the museum randomly or following a pre-planned journey, or a fisherman who goes fishing for marine species and is caught in an adventurous journey.

EMOTION

Three groups out of 9 (total of 8 participants) connected the idea of an '*emotional journey*' within a museum experience. This strategy can be combined with the theme of *adventure*, the only difference is that animal species which are part of this plot need to be helped in some way by the users and this help can make a difference in their lives (making the adventure more emotional). Here every users' choice has an impact on the story. If users choose

not to help a particular specie, the whole game can be compromised. *Emotion* is linked to the act of helping some species and taking care of it.

TAKEAWAYS FROM STUDY #4

From this study, I extracted that gamification and storytelling play an essential role in the design of joyful museum experiences targeted at teenagers.

Teens have demonstrated an interest in the search for, and discovery of, exhibits by challenging themselves through clues, riddles, and quizzes. Also, time is seen as valuable due to the need to establish a deadline for completing the experience. This generation is also keen on collecting pieces, similar to puzzle pieces, so that they can see a bigger picture at the end. Teenagers would like to tour the museum through the eyes of a specific species to understand more about the museum as well as about the specificities of the chosen species itself.

Teens have demonstrated an interest in being guided throughout the museum while immersed in a narrative plot. They tend to take the role of a leading figure or protagonist in the story for themselves. In parallel, teenagers are interested in helping and taking care of species, even in digital environments. *Adventure* is connected to the act of searching for, and collecting, exhibits through clues, a treasure hunt, and collection, while *Emotion* is entirely related to collection and simulation. This is very similar to the phenomenon of the Tamagotchi, a virtual pet that would die unless it was fed and cared for (Sherry, 2009).

In summary, from this study, teenagers highlighted their preference towards including gamification aspects and narratives driven adventures in their museum visits. Even though there was a small number of participants suggesting narratives, these were often integrated with game-elements. These results indicate that storytelling plots augmented with game mechanics, and games enhanced by storytelling plots were the preferred strategies highlighted by the teens themselves, to engage with museum visits; these two concepts were both highlighted as positive strategies for making museums more appealing. However, the disparities of suggestions about story-based apps VS game-based apps show that teenagers value gamification over narratives. Moreover, teenagers are creative and willing to share their stories when given the opportunity.

STUDY #5: ENGAGEMENT OF TEENAGERS

An analysis of how teen participants responded to the design session as a process was conducted using thematic analysis of the adjectives used by participants in their evaluations of the sessions. The goal for the evaluation was mainly to better understand the design session process and if teens enjoyed participating in it. I believe this is of interest to museum experience designers and cultural heritage professionals. Even though the participants were old enough to respond to a questionnaire, I opted to use a word association to evaluate it. According to Carl Jung (Jung, 1969) people connect thoughts, feelings, experiences and information by way of association. In the Association Test, a test used in psychology to study the organisation of mental life, the subject is instructed to state the first word that comes to mind in response to a word, concept, or other stimuli. In this study, the participants were told to report the first word that comes to mind in response to the co-design session carried. For this contribution, I am going to focus on the qualitative analysis of the word association made by the participants. Judging from the overall positive evaluation of the experience, participants enjoyed designing their ideal experiences in museums in a co-design session.

ANALYSIS

All the words describing their experience with the co-design methodology collected from the 155 teens were analysed to identify the categories and themes about the engagement of teenagers in participating in a co-design session. I used Thematic Analysis (Braun & Clarke, 2006) and NVivo 11 to organise the analysis. A detailed analysis of the words was conducted to evaluate the teenagers' enjoyment in taking part on the sessions. I firstly started coding the words. All words were transcribed into NVivo 11 (I refer to them as adjectives) and then categorised into 17 preliminary codes (brief description of what is being said), highlighting patterns and trends emerging from participants' adjectives. Then, these codes were sorted into 9 subthemes, and finally, the codes were grouped into 3 overreaching themes. The relation between codes and themes was double checked by me to guarantee the same meaning. A thematic map with codes, subthemes and themes was generated as shown in Table 13 below.

Table 13. *Map of the thematic analysis conducted over the teens assessment of the session: the one-word evaluation by participants generated codes (column "count" shows us how many adjectives each code encompasses), then these codes generated subthemes, and finally themes. Column "total" indicates how many adjectives each theme comprises.*

Code	Frequency Count	Subtheme	Theme	Total frequency
coolness	51	Interesting	POSITIVE	136
notable	34			
fun	7			
interaction	12	Collaboration		
collaborative	9			
learnable	2			
creative	13	Innovation		
innovative	6			
easy	2	Simple		
tricky	6	Complex	NEGATIVE	11
uninteresting	2	Unexciting		
not appealing	1			
uncomfortable	1	Obtrusive		
repetitive	1			
different	6	Diverse	NEUTRAL	8
indifferent	1	Somewhat		
more or less	1			

RESULTS

POSITIVE EVALUATION

Inside the *Positive Evaluation* theme (136 adjectives), I inserted all the subthemes which are related to positive experiences about the co-design sessions that teens took part in. I coded 4 subthemes for this theme: (i) *interesting*, (ii) *collaboration*, (iii) *innovation*, and (iv) *simple*.

For the subtheme *interesting* I coded (i) the adjectives that related to the 'coolness' of the session, and aesthetic qualities of attitude, behaviour, comportment, appearance and style which is generally admired, such as: *amazing* and *appealing*; (ii) the adjectives that describe the co-design session as 'notable', worthy of attention or notice, such as: *impressive* and *remarkable*; and (iii) the adjectives related to having 'fun', enjoyment, amusement, or light-hearted pleasure within the session, such as *hilarious*.

For the subtheme *collaboration* I coded (i) the adjectives regarding 'interaction', reciprocal action within the session and the other participants, such as: *dynamic* and *interactive*; (ii) the adjectives regarding 'collaborative' behaviours, where two or more parties work together, such as: *brainstorming* and *sociable*; (iii) and the adjectives related to 'learn', gain or acquire knowledge of something through experience, or being taught together with the other participants, such as *thoughtful* and *educational*.

For the subtheme *innovation*, I coded (i) the adjectives that defined the session as something 'creative', relating to or involving the imagination or original ideas, especially in

the production of an artistic work, such as *original* and *unique*; and (ii) the adjectives concerning the session as 'innovative', featuring new methods – advanced and original, such as *evolution* and *future*.

For the subtheme *simple*, I coded the adjectives which featured the experience as 'easy' to take, presenting no difficulty, such as *approachable* and *easy*.

NEGATIVE EVALUATION

Inside the *Negative Evaluation* theme (11 adjectives), I inserted all the subthemes which are related to negative experiences regarding the co-design sessions. I coded 3 subthemes for this theme: (i) *complex*, (ii) *unexciting*, and (iii) *obtrusive*.

For the subtheme *complex* I coded the adjectives that described the session as 'tricky', requiring care and skill because difficult or awkward, such as *complicated* and *complex*.

For the subtheme *unexciting* I coded (i) the adjectives that referred to the session as 'uninteresting', not arousing curiosity or interest; and (ii) the ones concerning the session as 'not appealing' such as *awful*.

For the subtheme *obtrusive* I coded (i) the adjectives that described the session as 'uncomfortable', causing or feeling slight discomfort, such as *annoying*; and (ii) the ones that described the session as 'repetitive', the action of repeating something that has already been said or written, such as *repetition*.

NEUTRAL EVALUATION

Inside the *Negative Evaluation* theme (8 adjectives), I inserted all the subthemes which refer to the co-design session as impartial, not helping or supporting either side – positive nor negative. I coded 2 subthemes for this theme: (i) *diverse*, and (ii) *somewhat*.

For the subtheme *diverse* I coded the adjectives that described the session as 'different', not the same as another similar activity – unlike in nature, form, or quality that the participants are usually used, such as *different* and *fishes*.

For the subtheme *somewhat* I coded (i) the adjectives that described the session as 'indifferent', having no particular interest or sympathy, such as *unconcerned*; and (ii) the ones that described the session as 'more or less', neither very good nor very bad, such as *so-so*.

TAKEAWAYS FROM STUDY #5

To better understand and evolve the process used to gather teens contributions, it is important to understand the participants' perceptions and impressions of the co-design session.

The value they assign to this process helps create an understanding of whether teenagers were excited and willing to join the session to contribute their ideas about designing mobile technology to enhance their own experiences in a natural history museum. The word-association method of gathering feedback about the sessions is a procedure that involves investigating which meanings related to the session are stored in memory. Judging from the overall positive evaluation of the experience, participants enjoyed designing their ideal experiences in museums in a co-design session. Furthermore, as a limitation of this analysis, we cannot know whether the students summarized the actual co-design session; perhaps they enjoyed the co-design session simply because it was not a regular lecture in the same classroom.

CONCLUDING SECTION: STUDIES #3-#5

In light of this set of research studies about the creation and deployment of a framework for engaging teenagers in the design of interpretative exhibitions, I divide the main conclusions into five topics: (i) teenagers as designers of museum experiences; (ii) what teenagers are interested in encountering during a mobile museum tour; (iii) the game mechanics that teenagers most value in a museum; (iv) the storytelling plots that teenagers most value in a museum; and (v) the sharing of memorable museum experiences.

Given the opportunity, teenagers are excited to share their ideas about how they would prefer to engage with museums, as they enjoyed designing their ideal experiences in museums during a co-design session. I believe that being part of these co-design sessions did not increase the chance of the process outcome be unsurprising and, as such, less interesting for the target audience. In fact, participants were very keen in having the possibility of experiencing their ideas into tangible prototypes.

Teenagers are interested in interacting with museum exhibits through cutting-edge technologies about which they know little but that they are excited to try out, such as AR, beacons, and image recognition to unlock digital content. Also, they showed an interest in checking 3D models of the exhibits to examine their details, as these exhibits are locked and untouchable behind a pane of glass. Teenagers are interested in taking different tours that allow them to interact with various exhibits on separate visits. Moreover, they are keen to learn about the story behind the museum building.

The game mechanics found in the first analysis of 'design patterns' are very similar to those found in the analysis of 'game mechanics and narrative plots'. The results from Sheet A came from the same sample of participants – hence, accounting for the similarity between these results. However, the analysis of 'game mechanics and narrative plots' was broader than the first, as it gathered the participants' ideas about narrative plots to complement the game mechanics, thereby establishing a bigger picture of what teens are interested in encountering during a museum mobile tour. The drawings from *Sheet B: interface design sheet*, displayed more mobile features that had not been detailed on the previous *Sheet A: concept sheet*. I can point out that, with Sheet B, participants expressed themselves better regarding the mechanics of the envisioned mobile museum experience. Teenagers were fascinated by their ideas and concept when sketching the interface of the application; in doing that, they started adding features that did not emerge from the textual description of their ideas. They expressed themselves better through the sketches of mobile features rather than by the description of them. I conclude that Sheet A, concept sheet, worked better for the narratives underlining the

experience, while Sheet B, interface design sheet, worked better for the detailed description of the mechanics underlining the experience.

Clues, treasure hunts, quizzes, collections, and timeout strategies are game mechanics that could increase teenagers' engagement with, and interest in, visiting museums. The deployment of clues and the search for elements within a museum experience could work not only to enhance their museum experience but also as a possible means of increasing their knowledge by solving the clues given. Museums are open learning houses and can make use of these game mechanics to assess knowledge, such as by using a quiz. This type of gaming technique is meant to encourage friendly competition among players in terms of who is best at completing the task. The collection of items would be a welcome strategy for engaging teens, as after the items are collected, they would form a bigger picture at the end. Timeout strategies must be carefully crafted into the logic and purpose of the museum visit as, otherwise, the result could be that teens are pushed through the exhibit too quickly, which means their goal becomes to finish the visit rather than to enjoy it.

This set of research studies highlighted the fact that gamification and storytelling go hand in hand. Teenagers are keen to be the protagonists of exciting adventures. Moreover, a thrilling, emotional journey can lead teenagers to become more engaged with the museum experience.

Regarding the sharing of memorable experiences in the form of pictures and selfies, teenagers are eager to share, with others, their memories on social media channels, as well as to view photos taken by others and global ranking scores.

3.4. UNDERSTANDING HOW MUSEUM PROFESSIONALS SEE TEENAGE VISITORS

For this set of research studies, the main goal was to obtain insights from museums' Cultural Heritage Professionals (CHPs) and curatorship students about how they perceive teenagers in museum tours. For this set of research studies, I conducted two studies. For the first study (study #6), I used the '*framework for co-designing museum experiences*' to make a comparison between the views of 43 teenagers and the views of 17 future curators (i.e., curatorship students pursuing a master's in Cultural Management) on enjoyable museum tours targeted at teens. Then, for the second study (study #7), I led co-design sessions with a group of 12 CHPs from the Natural History Museum of Funchal, using the HP Reveal as presented in study #2. These sessions resulted in a series of tangible digital interactive prototypes developed and targeted at teenagers that were later tested by both CHPs and teenagers.

STUDY #6: CURATORSHIP STUDENTS DESIGN MUSEUM EXPERIENCES TOWARDS TEENAGERS

For this study, I used the venue of the Natural History Museum of Funchal (NHMF) as a context to foster creativity in teens and young museum curatorship students. I followed the *'framework for co-designing museum experiences'* presented in the previous studies. After gathering the results of the co-design sessions with 43 teens (15-17 years old) through thematic analysis of *Sheets A& B*, such results were shown to 17 students of museum curatorship course at the local university (average of 26 years of age). These students enrolled in the Master in Cultural Management were required to design an experience targeting the teenage audience's desires and preferences using the same framework. Subsequently, a comparison between the results assessed if the curatorship students are prepared to design meaningful experiences for the teens of today. The results showed that teenagers value games and interactions in the museum while curatorship students give more prominence to narration.

SAMPLE

I approached 43 teens aged between 15-17 years old through a local secondary school in Madeira Island. The students, enrolled in a professional course on multimedia, participated in one of the two sessions conducted during two days. The sample gathered, containing 30 males and 13 females with an average age of 17.12, was divided into 13 groups. Then,

researchers approached 17 students from the Master in Cultural Management at the University of Madeira, studying to be museum curators. These master students participated in one session. The sample gathered, containing 9 males and 8 females with an average age of 26, was divided into 4 groups.

PROCEDURE

For this co-design process, the group of teenagers was divided into groups of 3-4 people, and were given the two working sheets. The results from the sessions were communicated in the session with the curatorship students in order to make them aware of what teenagers would value for an enjoyable museum experience, and invite them to design an interactive experience targeted to this teenage audience. This design session was conducted in the same manner as the one that teenagers performed divided into groups of 3-4 people.

ANALYSIS

All the sheets of both groups (teenagers and curatorship students) were analysed in detail, using the same methodology as in the Study #3, '*Design Patterns'*. The relevant words and phrases that each group wrote on Sheet A and drawn on Sheet B were transcribed and then categorized into themes containing similar words emphasized by the participants. Moreover, the results generated from the sessions with teenagers for this study are very similar to the ones gathered in the study '*Design Patterns'*, as the methodology used was the same. After this analysis for the current study, the results from each group (teenagers and curatorship students) were compared against each other.

RESULTS

DESIGN WORK – TEENAGERS

A total of 310 transcripts were obtained. These transcripts were then grouped into similar words, from which four categories emerged (Fig. 20), namely *Gaming* (156); *Interaction* (92); *Localization* (31); and, *Social Media* (31).

The *Gaming* category is related to the desire of adding game elements to the digital experiences inside the museum. It encompasses the following words transcript: 'rewards' (25), 'quiz' (21), 'clues' (17), 'game' (15), 'treasure-hunt' (15), 'points' (11), 'riddles' (8), 'challenge' (7), 'collect' (6), 'unlock' (6), 'levels' (5), 'progression' (5), 'ranking' (5), 'score' (4), 'player' (3), 'shop' (2), and 'achievements' (1).

The *Interaction* category recalls the desire of the teenagers to have some interaction with the exhibits inside the museum. This kind of interaction could happen in three ways: (i) by receiving information about the exhibits, (ii) by the user taking a role inside the museum instead of being a regular visitor, (iii) and also with the kind of technology that they are desiring to have those interactions. I grouped this category into three sections regarding the type of interaction and information delivery styles that the teenagers would like to experience in the museum.

- Sub-category A) *the user's interaction with the exhibits* (68 transcripts) where the participants recalled words regarding having 'information in several types' (51) such as textual, sound, video and image. Also, to have the power to select options in form of 'categories' (15) in order to choose which kind of content they want to consume as well as 'different narratives' (2) they could follow.
- Sub-category B) *User take the role of an artefact* (6 transcripts), where the participants expressed the desire to 'see the museum through the eyes of an exhibit' (6) such as a shark, who its views would be different from the eyes of another animal such as a little turtle.
- Sub-Category C) *Technology* (18 transcripts) encompassed the technology that the participants wanted to use or interact with such as 'beacons' (13), 'QR Codes' (3) and 'Augment Reality' (2).

The *Localization* category relates to the desire of the teenagers to localize themselves inside the museum building and included words relating to movements within the museum as well as the discovery of exhibits. It encompassed words such as 'localization' (10), 'search' (9), 'discover' (7) and, 'map' (5).

The *Social Media* category is related with the desire of sharing the experiences on social media channels. The transcripts were grouped into the words: 'social networks' (14), 'photos' (11), 'news' (4) and 'friends' (2).

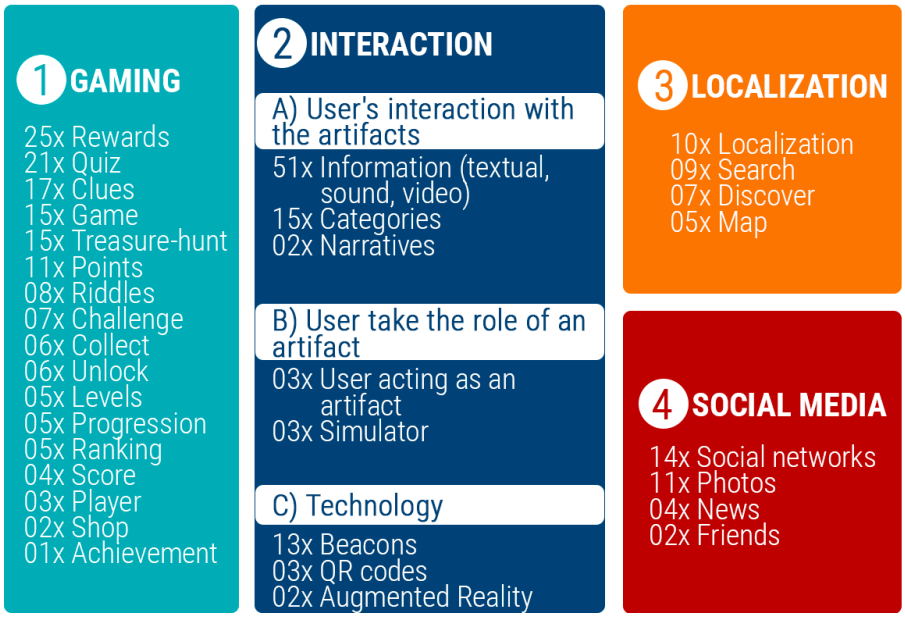


Figure 20. *Overview of the results from the co-design session with teenager that were then later showed to the curatorship students.*

DESIGN WORK – CURATORSHIP STUDENTS

The curatorship students had access to the categories derived from the sessions with the teens. Moreover, they were required to sketch an experience based on those categories which emerged as teenagers' preferences for interactive experiences inside museums.

A total of 76 transcripts were obtained from the design work of the curatorship students. These transcripts were then grouped into groups of words, and divided into four categories which were the same as the ones of the teenagers (Fig. 21), namely *Gaming* (32 transcripts); *Interaction* (31); *Localization* (8); and, *Social Media* (5).

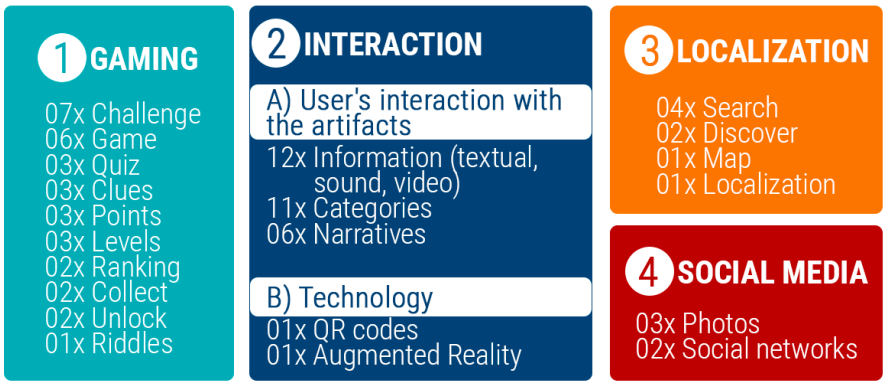


Figure 21. *Overview of the results from the co-design session with the curatorship students.*

The *Gaming* category encompassed the following words: 'challenge' (7), 'game' (6), 'quiz' (3), 'clues' (3), 'points' (3), 'levels' (3), 'ranking' (2), 'collect' (2), 'unlock' (2) and 'riddles' (1).

The *Interaction* category was grouped into two subcategories. Category A: *User's interaction with the artifacts* (29 transcripts) containing the following word groups: 'information' (12), 'categories' (11) and 'narratives' (6). Category B: *Technology* (2 transcripts) contained 'QR codes' (1) and 'augmented reality' (1).

The *Localization* category (8 transcripts) included words regarding 'search' (4), 'discover' (2), 'map' (1), 'localization' (1).

Finally, the *Social Media* category (5 transcripts) encompassed words about 'photos' (3) and, 'social networks' (2).

TAKEAWAYS FROM STUDY #6

Teenagers faithfully approach and adopt new technologies, while curatorship students assign more importance to the story that the museum wants to convey (Kelly, 2007). Curatorship students find it difficult to put themselves in the shoes of teenagers.

Although the categories emerged was the same in both groups, I noticed some discrepancies in the number of words within the categories. Teenagers assign more value to games and interactions in the museum than curatorship students do, as noted by the number of transcripts in the *Gaming* category by young people (156) and by curators (32): teenagers emphasized *games* almost 5 times more than curators did. By a significant amount, the teenagers emphasized game mechanics more than the curators did. These youths were born and brought up during the interactive technological boom and are more prone to embracing technology than are members of previous generations (Napoli & Ewing, 2000).

Teenagers wish to receive a *reward* when they accomplish a task, which is something that the curatorship students did not consider. The desire for *rewards* leads me to think about the extent to which these teens yearn for achievements in the form of rewards. Alternatively, what kind of rewards for their achievements must they receive in order to make a museum experience sustainable? Although the curatorship students had access to a list of teenagers' preferences, they did not think about rewarding the teens experiences.

What differs in the *Interaction* category is that teenagers have thought about interacting with the museum through the *role* of selected species exhibited in the museum. Through these types of interactions, they could have numerous experiences in the museums depending simply on their selection of which species' roles they want to take.

Another aspect to highlight are the *narratives*. Although teenagers spoke only twice about *narratives* (stories from and about the museum), the group of curatorship students, despite being small, assigned more prominence to narration (6 references). I can also verify

that the use of *technology* was significantly mentioned by the teenagers (18 transcripts), as compared to the curatorship students, who brought up technology only twice.

The *localization* category was the only one that did not have many discrepancies between the two groups. Nevertheless, the word *location* has been detected more often in the group of teenagers than in the group of curatorship students: teenagers emphasized 4 times more *location* than curators did. I can conclude that teenagers value the mechanics of interacting with species more than the curatorship students do. Teenagers strongly referenced the *social media* section as being highly relevant by using terms such as *social networks* and *newsfeeds* about the museum and by sharing their experiences with their *friends.* Although curatorship students were aware of this relationship between teenagers and social media at the beginning of their co-design session, they did not make use of it.

The discussion deriving from this study is centred around the teens preferences towards new technologies and the ability of curatorship students to use them in the design of museum experiences in order to enhance teenagers' enjoyment. However, the curatorship students did not thoroughly explore all technological options. Teenagers have a desire to speak, share, and be a part of the new technologies users' panorama. On the other hand, curatorship students prefer to think of the experience as a whole, without paying much attention to the type of technology that can be used. The curatorship students believe that the most prominent method of providing an enjoyable museum experience for teenagers is via story-based narratives, while the teens believe that the most appealing aspect is the implementation of game mechanics within the museum experience. Merging those perspectives – the narratives and the game mechanics – would create common ground between the teenage visitors and the content, thereby achieving an enjoyable visiting experience. Moreover, the reward that teens desire could be delivered in the form of the engaging experience itself.

STUDY #7: CULTURAL HERITAGE PROFESSIONALS DEVELOP MUSEUM-BASED DIGITAL EXPERIENCES TARGETED AT TEENAGERS

In this study, 12 Cultural Heritage Professionals (CHPs) from the Natural History Museum of Funchal (NHMF) took part in a co-design activity over 20 hours, aiming to create and deploy digital tours for teenagers aged between 16-19 through the HP Reveal software. I present the three mid-fidelity prototypes that derived from these design sessions. These were then tested by both 12 CHPs and 12 teenagers separately. The purpose of this comparison was to answer the following questions: Do cultural heritage professionals understand teenagers' needs and desires when it comes to designing engaging museum experiences for them? How do teenagers receive CHPs ideas, and how can CHPs learn from teenagers in order to improve museum experiences targeting this young audience? The difference in the results between these two groups (CHPs and teenagers) is a consequence of their experience with mobile apps and familiarity with teenagers' motivations. I report on lessons learned from the evaluation of these prototypes by both groups.

To note that I used the outcome of study #1 – '*Focus Group'* – to feed the current study. I had not integrated the ideas of the participants from the studies #2, #4 and #5 into this study. I decided to do this way as I would like to check if this sample of CHPs would give similar or different insights from the ones of the previous studies with teenagers developing museum concepts.

SAMPLE

CHPs from NHMF were invited to take part in a training course which would lead to the design and development of early concept prototypes of interactive tours aimed at teenagers visiting the museum. The group of CHPs who gave us permission to take part in this training course/research study [Appendix 12] was composed of 12 participants (aged from 41-54, 8 females and 4 males) which included 7 biologists, 2 tour guides, 2 technicians from their scientific library, and 1 member of communication personnel. This training course was carried out over two weeks and had a total duration of 20 hours (2 hours per business day).

A group of 12 teenagers (aged between 16-19 years old) from a local secondary school next to the museum was invited to test the interactive tours created by the CHPs. Unexpectedly, all the users were male, and I was unable to recruit females for this early evaluation. Parents and legal tutors signed consent forms on behalf of their children to take part in the study [Appendix 13]. After obtaining all the necessary permissions, I scheduled a day for the testing.

PROCEDURE

To answer the above questions, I followed the results from Study #1 – '*Focus Group'* – where teenagers' views regarding museum tours yielded the following categories: (i) interaction with the exhibits, (ii) multimedia within the tour, (iii) new and less mundane experiences at museums; (iv) their interests reflected on the tours. These outcomes were communicated to the group of CHPs from the NHMF. This group of CHPs was then instructed how to design and use free digital interactive media tools to develop their ideas.

CO-DESIGN SESSION WITH CULTURAL HERITAGE PROFESSIONALS

The CHP group was split into teams of 4 and given around 14 hours to develop an interactive museum tour for teens, bearing in mind that teenagers would test their interactive tours later. The proposed schedule based in Study #2 – '*Development of gaming museum experiences through an Augmented Reality tool*' – was the following:

03h – Ice breaking and brainstorming

Taking into account the information gathered on the focus groups carried on what teens would add to museum tours to inspire them to visit these institutions, the CHPs were split into groups and invited to think about an 'ideal experience' to engage teens in their museum (Fig. 22). This exercise was designed to break the ice between the participants. To boost their imagination and critical spirit, they were free to think that everything was technically possible.

01h – Introduction to the practical part

CHPs were introduced to the 14-hour training course. The following topics were summarised: (i) definition of the interactive tour experience, (ii) script writing of the tour experience, (iii) development of the digital content (videos), (iv) uploading of the digital content to the HP Reveal software, and (v) testing and evaluation of the tours.

02h – Definition of the tour concept

The participants, divided into groups, decided which of the museum's rooms to focus on, which points of interest (POIs) to work with and the concept of their tour experiences. Participants were encouraged to think in terms of storytelling as well as game mechanics to guide the teenage visitor through the POIs, bearing in mind that the digital content to unlock in each POI would be a multimedia video made by them. These videos needed to include an indication to guide the visitor to the following POIs.

04h – Script writing of the tour experience

After defining the tour concept, participants began creating scripts for the videos to be unlocked at each POI. For each POI, they were required to describe: 1) which location the video is related to; 2) if any image appears; 3) dialogue, if any; 4) how they would guide the user to the next POI.

06h – Development of the digital content (videos)

With the script finished, the participants started creating the video for each POI. The content of these videos was produced by the participants on their own. Some of them recorded a theatrical performance while others recorded their voices and put together images and animations. The videos and voices were recorded with an iPhone 6, and the manipulation and animations of the videos were made in native video software on their own computers (Windows Movie Maker, Keynote, and PowerPoint).

02h – Uploading of the digital content to the HP Reveal software

The participants were instructed on how to upload their videos to the HP Reveal studio and how to use the HP Reveal app to perform the digital tour with the content created. The HP Reveal software (Fig. 23) is one of the many easy and free tools available on the market. It was chosen for this activity as it was ranked highest by users on Google Play and offers a visually clean studio within which to upload digital content. HP Reveal is AR software which allows us to see and interact with the world through digital content. The digital content can be as simple as a video and a link to a web page, or as complex as a live 3D animation. For the purpose of simplicity and the CHPs' abilities in this area, and as similar to the study *'Development of gaming experiences through an Augmented Reality tool'* from Study #2, I chose to make each piece of content rendered as a video. Users of this software need to select a trigger image which unlocks the digital content. The trigger image can be a picture of an exhibit in the museum or a picture of its label. After selecting the trigger image, it is necessary to upload the digital content. Therefore, when the user's smartphone camera points to that trigger image, it will unlock the digital content previously uploaded.

02h – Testing and evaluation of the tours

All the CHPs tested the tours developed (in this order: Tour #1, Tour #2, Tour #3), answered surveys, and commented on their experience (Fig. 24).

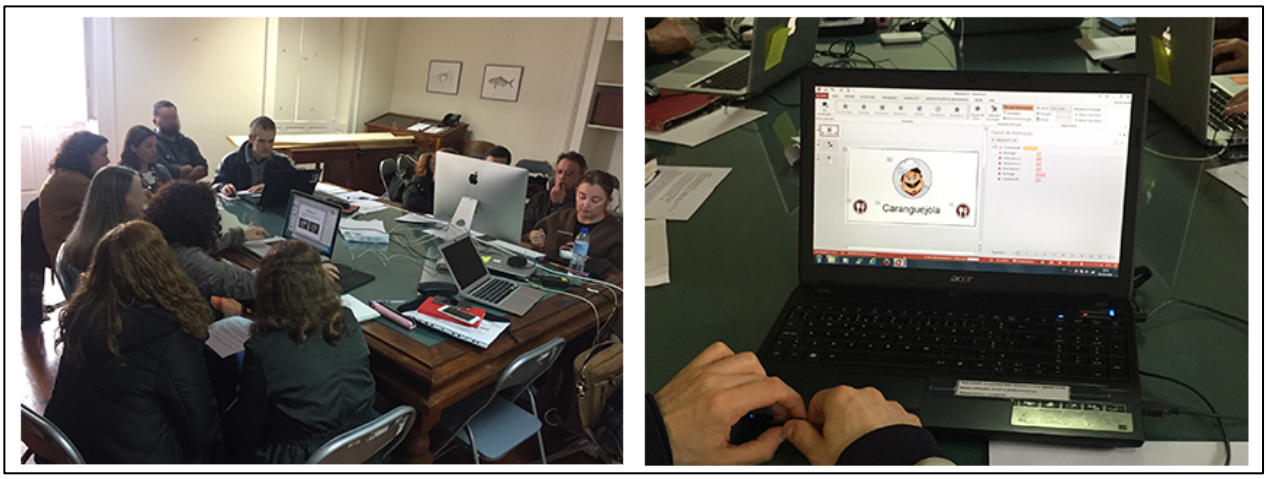


Figure 22. *CHPs split into groups working on their AR experiences targeted to teenagers.*

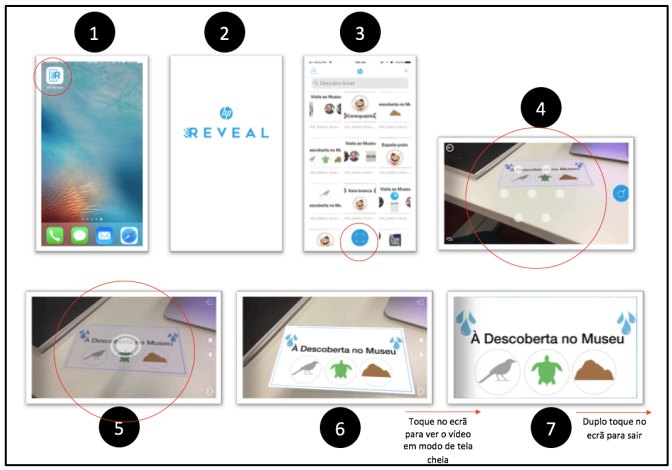


Figure 23. *Tutorial of the HP Reveal app shown to the teenage participants before the experiments. Point 6 says "click on the screen to watch the video in full screen". Point 7 says "double click on the screen to exit the video".*

Figure 24. *CHPs testing their experiences in groups.*

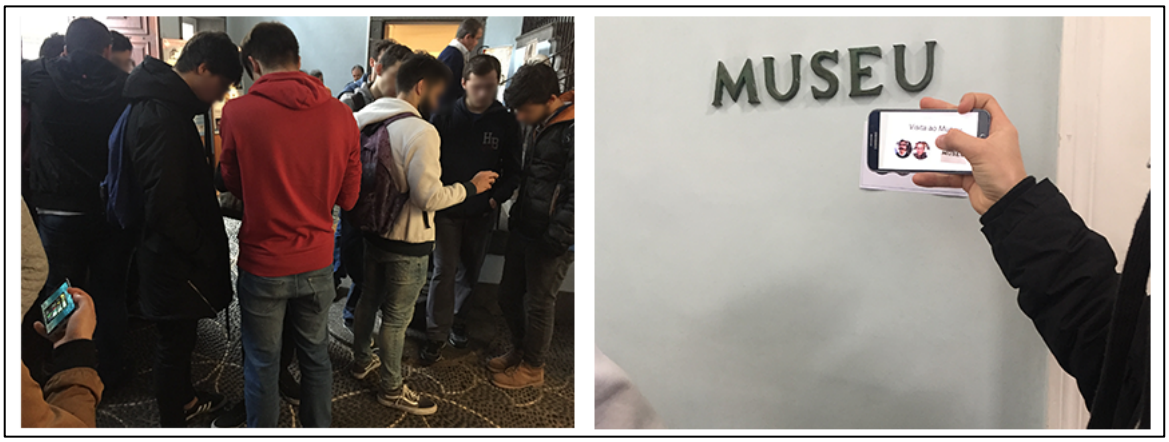


Figure 25 . *Teenagers, split into groups, testing the experiences that CHPs developed.*

TESTING BY CULTURAL HERITAGE PROFESSIONALS AND TEENAGERS

Once the tours were prototyped, all the CHPs and teenagers tested them separately, answered surveys, and were briefly interviewed about what would they change about the experience, and how, in order to be more attractive for teenagers.

As I had limited devices to test the prototypes, I split the sample of teenagers in four groups of three and gave a smartphone per group (Fig. 25). The students did the tours at the same time but always remained in their groups (order: Tour #1, Tour #2, Tour #3). After the end of each tour, teenagers came to a room where they answered surveys and commented on the experience they had just had.

Finally, I compared the results of each tour between both groups (CHPs vs teens).

ANALYSIS

The experiment, conducted at the museum, incorporated different research methods. This is a between-subjects study design (between groups: CHPs vs teens), where the different people test each one of the three conditions. I used SPSS to run the quantitative analysis, and the Mann-Whitney U Test was chosen as it is a non-parametric test that is used to test whether two sample means are equal or not. I applied the Museum Experience Scale (MES) [Appendix 14], the Multimedia Guide Scale (MGS) (Othman et al., 2011) [Appendix 15], and the Positive and Negative Affect Schedule (PANAS) (Watson et al., 1988) [Appendix 16].

The MES measures a visitor's overall experience in museums, particularly the engagement with the exhibition. This scale has 4 components: (i) the engagement with the exhibitions and exhibits; (ii) the knowledge/learning gained from the exhibition and exhibits; (iii) the meaningful experiences from the interaction with the exhibitions/exhibits and/or other

visitors, and (iv) the emotional connection with the exhibits/exhibitions. Each component contains 5 questions each.

The MGS measures reactions to the usefulness and usability of multimedia guides. This scale has 17 questions within 3 components: (i) the general usability of the guide; (ii) learnability and control, and (iii) the quality of interaction with the guide.

The PANAS scale describes different feelings and emotions regarding an activity.

In one hand, by applying both the MES and PANAS, I would be able to answer how CHPs and teens perceive and feel connected with the digital museum tours. On another hand, by applying the MGS, I would foster discussion on which problems encountered with the mobile tours both groups reported. Given that these quantitative measures can helpfully complement qualitative information about visitor experience, comparing the results gathered from CHPs and teens would help us to understand whether CHPs perceived teenagers' need and desires when it comes to museum tours, as well as how CHPs could learn from these results to improve museum experiences targeted at teenagers.

At the end of each tour, both CHPs and teens were briefly interviewed about their experience and what they thought teenagers would have liked most about it. These comments were recorded and transcribed. I used Thematic Analysis to analyse the data gathered (Braun & Clarke, 2006) and NVivo 11 was used to organise the qualitative analysis for each tour. To note that the CHPs and teenagers never met in person for these discussions, these were conducted separately. I believe that having a discussion with both groups at the same time had not been beneficial as teens were likely to look at the CHPs as a superior hierarchical figure who develop the mobiles strategies which would prompt teenagers to give "the right answer" instead of being direct and honest about their concerns.

RESULTS

Within this section, I describe each one of the three prototyped tours created by the CHPs, part of its script to contextualise the reader, and the results from the scales and interviews with CHPs and teenagers separately. The script gives the necessary information about the content to be found at each POI. To complete their scripts, the CHPs also wrote all the narrator's speeches to record and add to the videos, but for the purpose of simplicity and page constraints, I have chosen not to include all the narrator/character speeches, but outline the topics portrayed in these lines. In [Appendixes 17, 18, 19] the reader has access to the markers to unlock these tours in the HP Reveal software.

TOUR #1 DISCOVERING THE MUSEUM

Tour #1 [Appendix 17] was created to make visitors aware of the scientific library as it is almost unknown to the museum's visitors. It encompasses four different POIs and at the end, invites the users to explore the real library there. This tour makes use of web links with detailed information about the POI, and of time-lapse videos to show the visitor where they need to go next. Detailed information about Tour #1 can be found in Figure 26 and Table 14.

Figure 26. *Overview of the 1st POI from Tour #1, upper left to lower right: 1) Trigger image located at the entrance hall; 2) Video starts with information about the MHNF; 3) The scientific library of NHMF; 4) Frame from the end of the video launching the challenge: to look around the museum for those three symbols.*

Table 14. *A part of the script from Tour #1.*

Theme	Getting to know the Scientific Library
Plot	A narrator gives information about the museum and lets the users know they can find more detailed information in the Scientific Library about certain exhibits in the museum.
Number of POIs	4
Mechanic	Information on the POI + time-lapse video of the route from one POI to another POI.
Video development	Keynote: voice of narrator accompanying images / text / videos appearing.
End of each POI	Time-lapse video of the walk from one POI to the next POI.
1st POI	Entrance hall (01m 45s)
Topics	This first POI gives an introduction to the museum and makes reference to the Scientific Library as it is hidden and many visitors, especially young people, do not know that it exists. This POI launches a challenge to find three symbols in the museum that are related to certain exhibits which will allow the user to learn more about them.
Going to the next POI	Time-lapse video of the walking route from this POI to the 2nd POI (Sea Bird).
2nd POI	Sea Bird (00m 22s)
Topics	1) Scientific name and origin of the species accompanied by book covers that can be found in the library, 2) Web link that gives access to a web page about specific information about the Sea Bird.
Going to the next POI	Time-lapse video of the route from this POI to the 3rd POI (turtle).
3rd POI	Turtle (00m 20s)
Topics	1) Scientific name and origin of the species accompanied by book covers that can be found in the library, 2) Web link that gives access to a web page giving specific information about the turtle.
Going to the next POI	Time-lapse video of the walk from this POI to the 4th POI (Basalto Stone).
4th POI	Basalto Stone (00m 38s)
Topics	1) Scientific name and origin of the object accompanied by some book covers that can be found in the library, 2) Web link that gives access to a web page showing more information on the Basalto Stone.
Ending	The narrator thanks the user for making this tour and invites him to visit the library. Shows a time-lapse video of the walking route from the Basalto Stone to the Scientific Library.

TOUR #1: QUANTITATIVE ANALYSIS BETWEEN GROUPS

Data shows that teens (MDN=4.4) could obtain more *knowledge/learning* with Tour #1 than the CHPs (MDN=3.44), and this was statistically significant (U=21.5, p=0.004). Also, it emerged from the data that teens (MDN=3.8) had a more *meaningful experience* than CHPs had (MDN=3.2), this being significant (U=24.5, p=0.006). Regarding *learnability and control*, this tour ranked higher among teens (MDN=4.67) than among CHPs (MDN=3.83); the

difference is statistically significant (U=21, p=0.003). To end with, teens scored higher on *negative affect* (MDN=1.1) than CHPs (MDN=1), and this again was statistically significant (U=41, p=0.048).

Tour #1: Comments from CHPs and teens

Nobody clicked on the **links** in the videos, in fact, no one understood that the 'www' image (Fig. 27) was clickable. One of the CHPs only realised this at the last POI. All CHPs agreed that links need to redirect users to easily consumable information; a video, for example, rather than a webpage. At the design stage, CHPs were convinced that the 'www' image would be noticed by teens, yet none of the teenagers understood that the image was clickable.

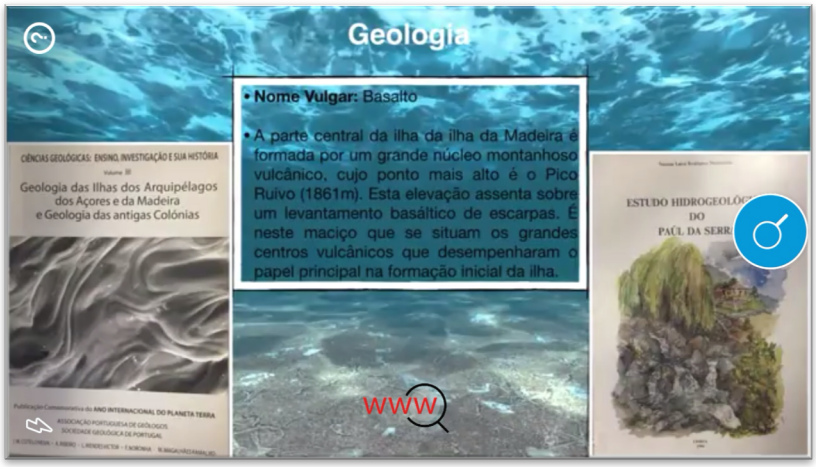


Figure 27. *Screenshot of the video displayed on the 4th POI from Tour #1 displaying the "www" image linked to a webpage.*

The CHPs considered Tour #1 very **interesting** from the experience design point of view but also highlighted that it would need **more detailed information** about the exhibits to be informative and impactful enough for teens to engage with. Moreover, CHPs agreed that the POIs were not consistent among themselves, the 1st POI was **very long** in relation to the others that were very short and light in information. Both groups agreed this tour was **too short.** Teenagers said that on top of being short and fast, they could not stop the video to read what was written on it. As a consequence, only six teenagers (two groups) realised they were supposed to go to the library at the end of it. However, they could not go because the door that gives access to the stairs leading to the library was closed, and, as a consequence, the teenagers did not end up going to the library as the CHPs had envisioned. Moreover, both teens and CHPs **would advise to change the clues** guiding visitors from one POI to the next. Two CHPs reported they would lower the time-lapse speed. One teenager reported the time-lapse video as being too fast and therefore it was hard to remember where to go next. Three CHPs pointed out

that it would be valuable to **add more sounds and multimedia videos** to this tour to captivate visitors. CHPs also thought that having a headset would improve their visit and minimise distractions; reducing **background noise** in the museum such as footsteps and people talking.

TOUR #2 GASTRONOMIC ROUTE

Tour #2 [Appendix 18] was created to get visitors to discover some marine species in a different manner. This tour was different because it had a chef character that guides the user through a series of curiosities and recipes for a selection of marine animals. This tour uses pictures of animals to prompt the users to search for them and unlock the digital content. It includes four different POIs and at the last one, invites the users to click on a book which will lead them to view a PDF with more recipes. Detailed information about Tour #2 can be found in Figure 28 and Table 15.

Figure 28 . *Overview from the 1st POI of Tour #: 1) Trigger image; 2) Chef welcoming the users; 3) Chef introduces his recipe and invites the user to search for the main ingredient in the museum; 4) Ending frame of the video depicting the scabbard fish for the user to look for in the museum's premises.*

***Table 15**. A part of the script from Tour #2.*

Theme	Gastronomy
Plot	Chef of the old palace (now the museum building) invites the user to learn more about the dishes that he used to cook at banquets, guiding the user through the edible marine species in the museum.
Number of POIs	4
Mechanic	PowerPoint: Curiosities about specific marine species at each POI along with a picture of the species cooked on a dining plate.
Video development	Narrator voice of the main character accompanying images / text / videos appearing.
End of each POI	Drawing of the next animal in the museum that users have to look for to go to the next POI.
1st POI	Entrance Hall (00m 43s)
Topics	This first POI presents the narrator as a chef who will guide the users to visit the museum and show them three marine animals that are usually cooked.
Going to the next POI	Drawing of the next animal (swordfish) that users have to look for to reach the next POI
2nd POI	Swordfish (00m 47s)
Topics	Curiosities about the Swordfish along with a picture of this fish cooked on a dining plate.
Going to the next POI	Drawing of the next animal (Xara-branca) that users have to look for to reach the next POI
3rd POI	Xara-branca (00m 41s)
Topics	Curiosities about the xara-branca along with a picture of this shark cooked on a dining plate.
Going to the next POI	Drawing of the next animal (caranguejola) that users have to look for to reach the next POI.
4th POI	Caranguejola (00m 37s)
Topics	Curiosities about the caranguejola along with a picture of this crab cooked on a dining plate.
Ending	The chef says goodbye and invites the visitor to learn more about other fish recipes by clicking on a book that appears on the screen (Fig. 29).

TOUR #2: QUANTITATIVE ANALYSIS BETWEEN GROUPS

Data shows that teens (MDN=3.8) were *emotionally more connected* with Tour #2 than CHPs (MDN=2.8), and this was statistically significant (U=29, p=0.013).

TOUR #2: COMMENTS FROM CHPS AND TEENS

Both CHPs and teens found the **content interesting** and were **aware of the link** displayed in the last POI (Fig. 29). CHPs argued that having culinary curiosities of the species

was very good, and also mentioned that it is a non-common aspect interesting to explore. Two CHPs suggested that it is necessary to deliver thematic content to engage more teen visitors. From the teenager's point of view, they thought it was nice to have a tour as different and interesting as this one, and that all the content displayed at each POI was understandable.

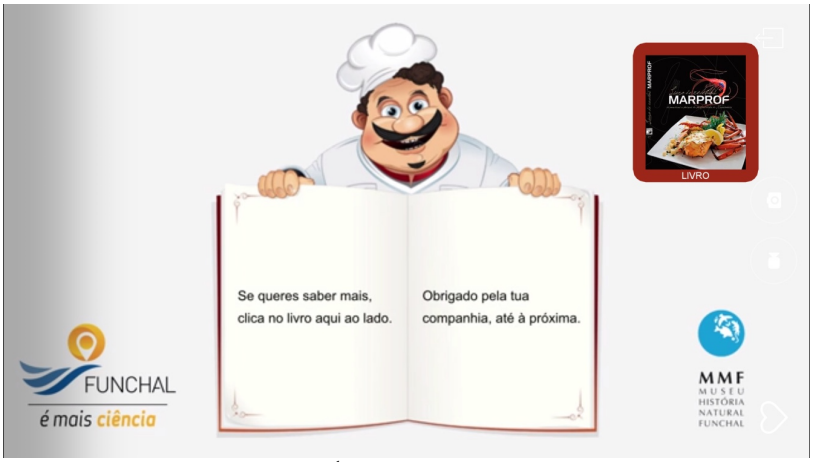


Figure 29. *Screenshot of the video displayed on the 4th POI from Tour #2. It is possible to see the book image which would lead to a webpage to see the PDF of the recipes.*

However, only four CHPs mentioned that this tour **did not focus on what the museum is about,** because it was mainly centred around gastronomic curiosities of some species in the museum. Also, three CHPs mentioned that the **words displayed on the device screen were too small** and difficult to read, although the teens mentioned they **could read** the text well on their mobiles. All CHPs mentioned that the **graphics were good**, and only three of the CHPs **would change the clues** giving more information to the user regarding the location of the next POI since those who come to the museum for the first time would not know the rooms. Two of the CHPs mentioned they would **add more and better animation to captivate** teens, while teens pointed out that it would be more attractive if there were 3D images of the species to interact with. Interestingly, two CHPs argued that they were almost certain that this tour **would not be appealing** to teenagers. However, the teens mentioned this tour was better and more **interesting** than they were expecting and agreed it worked well to simultaneously combine texts and the narrator's voice. One teenager mentioned that he would **add more expression** to the voice of the narrating character in order to make it more appealing. The students were in agreement that this was a good tour because they had time to observe the museum, and were able to explore it more freely than the first tour.

TOUR #3 VISITING THE MUSEUM

Tour #3 [Appendix 19] was created to acquaint visitors with the museum by following and assisting them through a guided tour hosted by two digital characters. An old male character is giving a guided tour to a teenage character. During this digital tour, the curious teenage visitor asks questions about specific animals, and the guide answers them by showing some videos of those animals in their natural habitat. This tour uses the trigger images as clues to prompt the users to search for their locations in order to unlock the next piece of digital content. The tour includes four different POIs, and in each of them, shows videos of animals in their natural habitats. Detailed information about Tour #3 can be found in Figure 30 and Table 16.

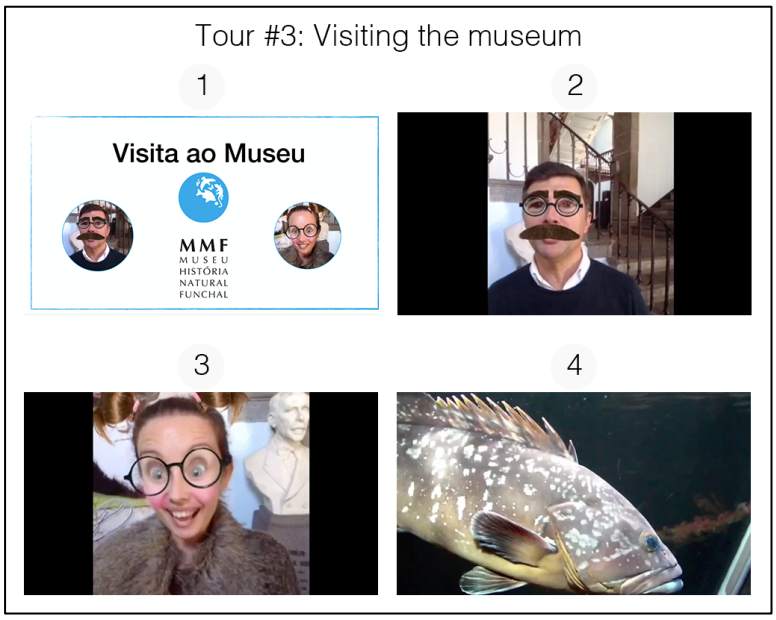


Figure 30. *Overview from the 1st POI of Tour #3: 1) Trigger image; 2) Adolfo character welcoming Bruna; 3) Bruna character very curious; 4) Video of the Mero in its natural habitat.*

Table 16. *A part of the script from Tour #3.*

Theme	Visit between a male guide and a female teenage visitor.
Plot	Theatrical performance from two characters interacting with each other: Mr. Adolfo as director of the museum gives a guided tour to the curious teen girl Bruna who is always asking questions.
Number of POIs	4
Mechanic	Bruna asks questions about the museum and the species exhibited. Mr. Adolfo answers and shows videos of the species in their natural habitat.
Video development	Two people acted the character parts and were recorded through video software chosen by the participants – Crazy Helium Voice Changer. Besides modifying them aesthetically through filters (hair, glasses), it also altered their voices. The images and voices of the characters were accompanied by video clips of the animals in their habitats.
End of each POI	The characters verbally announce the next location and the trigger image for the next POI appears.
1st POI	Entrance Hall (00m 48s)
Topics	The characters meet and begin talking about the building's history, and that it even has an aquarium, making Bruna curious and wanting to see it.
Going to the next POI	The characters verbally announce the next location and the trigger image for the next POI appears (Aquarium).
2nd POI	Aquarium (00m 52s)
Topics	Adolfo tells Bruna that the Mero fish is one of the oldest in the aquarium, raising curiosity about him from Bruna. She asks him more questions about the fish. We observe videos of the fish in its natural habitat at the sea.
Going to the next POI	The characters verbally announce the next location and the trigger image for the next POI appears (museum entrance on the 1st floor).
3rd POI	Museum Entrance (01m 16s)
Topics	Bruna is surprised to see sharks, and Adolfo talks specifically about a shark that is on a shelf. Includes videos of this shark in its natural habitat.
Going to the next POI	The characters verbally announce the next location and the trigger image for the next POI appears (bird: cagarra)
4th POI	Cagarra (01m 40s)
Topics	A video of this bird appears in its natural habitat at the same time that Adolfo is talking about the species.
Ending	Bruna says goodbye and thanks Adolfo for the visit. Adolfo tells her to always come back and to bring friends to learn about the other species in the museum. The users can see a "thank for watching" screen.

TOUR #3: QUANTITATIVE ANALYSIS BETWEEN GROUPS

CHPs (MDN=3.0) ranked more on the *quality of interaction with the guide* under the Tour #3 than the teens did (MDN=2.7), and this was statistically significant (U=31, p=0.017). However, it was also significantly reported (U=27.5, p=0.004) that teens were more *negatively affected* by this tour (MDN=1.5) than CHPs (MDN=1.0).

Tour #3: Comments from CHPs and teens

Both CHPs and teens agreed that the characters' **voice would have to be changed**. Only one CHP mentioned that he **would add text** or keywords to the video displayed so that the content would be more understandable, whereas the teens mentioned they could not perceive anything because there was no accompanying text. The CHPs rated this tour as **the most interesting** and also mentioned that due to **background noise**, the dialogue between the characters was not understandable. The CHPs involved in the creation of this tour also reported that the **software used to manipulate** the characters voice and appearance was very limited, but they preferred this solution as it meant less work when editing the videos. They also mentioned the initial idea was to model a 3D image of the character Adolfo but did not have this skill. Additionally, one CHP pointed out that before going directly to the video of the species in their habitat, it **should show the species** in their exhibit shelves first, otherwise no-one would look at the real embalmed animal in the museum and would only see a picture on the screen of the smartphone. Only the teens **would change the characters** as they did not like the filters applied to the characters and the fact they did not move. They also argued that it would be better to have a real person guiding and talking to them directly rather than watching the characters in the app. CHPs felt that the **videos were interesting** to make the visit appealing and thought they removed the formality of the visit itself. However, only one teenager described the videos of the species as 'awesome'.

Takeaways from Study #7

In the following section, I reflect on the data collected in relation to my research questions for this study.

Do cultural heritage professionals understand teenagers' needs and desires when it comes to designing engaging museum experiences for them?

Despite having access to teenagers' ideas and preferences regarding exciting museum tours, it was hard for CHPs to include the interests of teenagers within the tours. CHPs had some trouble thinking of and designing experiences that the sampled teenage testers evaluated as pleasant. This was noted in Tour #3, in which the CHPs developed a simple story and characters that did not trigger excitement among the teens. Tour #2 was more positively rated by teenagers, while CHPs thought it was the tour that would least appeal to teenagers, as it did not reflect what the museum was about. CHPs found it difficult to put themselves in the teenagers' shoes. This is a noticeable fact, emerging from this study, could be partially explained by the fact that the sampled CHPs grew up and were educated in a very different era,

with different sets of technologies. While involving CHPs in the design process has value per se, I have seen the difficulties that this group experienced in terms of thinking about and understanding the museum through the teens' eyes. Allowing for error and learning from mistakes can be a strategy for raising awareness among CHPs with respect to the changing goals, strategies, and audiences of museums.

How do teenagers receive CHPs' ideas and how can CHPs learn from teenagers in order to improve museum experiences targeted at this young audience?

Concerning Tour #1, based on the Museum Experience Scale, the teenagers learned more from the exhibits of this tour than did the CHPs, as the CHPs already held this knowledge. Considering the topics of *knowledge*, *meaningful experience*, and *learning and control*, it is normal for the teens to manifest significantly higher values, as this was their first visit with the interactive guide. However, teens felt more *negatively affected* by the tour than did CHPs. This result highlights the fact that learning is not necessarily a motivation for teens to visit museums, though it seems to be a high priority among CHPs. Through this tour, I also learned that teenagers might be keen to discover places inside the museum that they were not previously aware existed. However, the results of this study indicate that museums should ensure that all paths leading to the completion of digital tours are not obstructed and should facilitate the passage of visitors, as the teens were not able to access the library as the CHPs had envisioned. Furthermore, the inclusion of links in the videos must be well-thought-out in terms of the design and usability levels; otherwise, the user may not be aware of them and may not click on the additional material. For example, CHPs argue that the links were something that the teens would not have missed, while all the teens did. CHPs operated on a preconceived idea. They projected their own perceptions and understanding of technology onto the teens, who interact with technology in very different ways. I also learned that CHPs should measure the amount of time that text appears on-screen, as if too much text is displayed in too short a time to read it, users end up frustrated. This issue stems from a first usability mistake made by interaction design beginners and shows that CHPs were not able to go beyond the basic issues of designing for mobile. Nor did they think about testing the technology to understand which issues could arise.

Tour #2's results, based on culinary recipes, indicated that teens were more *emotionally connected* to this tour than were the CHPs. The CHPs mentioned that this tour did not convey what the museum is about, yet it was the tour to which the teenagers felt more connected. It is interesting to note, again, how the teens' perceptions differed from those of the CHPs. Through Tour #2, I learned that the inclusion of several more informal themes than the ones carried out

in regular museum tours are viewed as positive and engaging, as the teens sought general and different overviews of the environment rather than specific information. I also learned that simple ideas and the simple development of videos (the case with this tour) might work better than complex ones (the case with tour #3).

Tour #3, based on the teens /curator dialogue, also yielded interesting results. Although the CHPs thought this would be an exciting tour due to the quality of information delivered through the videos and character interaction, the teenagers disagreed. For this tour, the teenagers reported being more negatively affected than did the CHPs. Here, I noticed a considerable difference between the views of CHPs and teens. This was due mainly to the distortion of the character voices and the filters applied to their images; the CHPs thought that this was the most engaging part of the tour, while the teens found the tour childish. The narrating voices were also hard to understand, which was a result of the filters applied. However, on a more positive note, the use of videos of the featured species in their natural habitat was seen as a positive element of the tour.

CONCLUDING SECTION: STUDIES #6-#7

In light of the results from this set of research studies that sought to understand how museum professionals see teenagers as visitors, I divided the main conclusions into three topics: (i) how curators perceive mobile experiences in museums; (ii) authoring tools to help museum professionals develop such experiences; and (iii) teenagers as museum visitors. I will summarise the findings from the studies under the three topics below.

Museum professionals believe that the most noticeable method of providing an enjoyable museum experience for teenagers is via story-based narratives. They prefer to think of an experience at a higher level – focus on the concept and not entering in the details of implementation. However, these professionals tend to operate using preconceived ideas about teenagers in general, which could compromise the entire experience.

The development of creative content and the use of free digital authoring tools, such as HP Reveal, seems to be viable solution for museums curators, in institutions that lack the funding to engage in improving their message and target teens audiences specifically. However, these tools are suitable for early prototypes. The derived experiences should be improved by taking into consideration usability and interaction design standards, as museum professionals do not have interaction design skills, and this lack could compromise the experience as a whole. Moreover, museum experience designers should conduct usability tests with the target users so that they understand what can be added or improved to foster a better and more exciting experience.

Teenagers have a desire to speak, share, and be part of new technologies, and they are eager to share their memories through social media. They also value game mechanics and interactions related to museum visits. The connection between teenagers' previous experiences and memories of the exhibition is positive and engaging. Moreover, teenagers do not like to be seen as children; hence, the implementation of images and sounds into a digital museum experience must be seriously considered in order to align with the teenagers' motivations and not with those of children. Also, teenagers manifested the desire to receive a reward when they accomplished a task.

3.5. DISCUSSION

Teenagers have the perception that museums are good places for informal learning. Nevertheless, these cultural heritage venues remain unappealing to them. In essence, results from the carried studies (Studies #1-7) highlight how much teenagers value technology, interaction, gaming, and adventure as must-have features for a mobile museum experience. They appreciate the integration of playful approaches with the learning goals of this institution, so to have more exciting and less mundane experiences. In fact, these results resonate with the broader literature, which indicates that young people today are born into a world flooded by novel technologies (Wikia, 2013). Combining teens' everyday engagement with cultural heritage spaces allows teens to see museums differently – as spaces that could provide engaging and fun experiences. The creation of links between knowledge of the exhibits represented in the museum and the visitors' daily practices (Pierroux et al., 2007) could engage visitors within an exhibition, as people usually invest their time in events based on past experiences and personal preferences (Dindler et al., 2010). Storytelling and game-based approaches can benefit museums by promoting joyful and exciting experiences, which have the potential to support meaningful learning (Edwards & Schaller, 2007; Ioannidis et al., 2013), thereby boosting the museum's learning goals while enhancing the playful aspects of the visit. Games can improve museums by promoting positive attitudes about museum spaces and by making museums fun destinations that promote meaningful informal learning combined with entertainment. **Gamification** and **storytelling** can go hand in hand. Teens' everyday engagement in relation to games is mediated through the adventure genre. However, there are some disadvantages to the use of gaming experiences in museums. Players could become fascinated with the screen and fail to observe the physical exhibit in the museum, which might not be the museum's goal. Curators of museums should focus on this group by not only designing the experience to be tailored to this specific public but also concentrating on a specific marketing campaign by advertising the fun that visitors are sure to have.

Working with teenagers to design, evaluate, or co-design can offer us a wide view of their world (Druin, 1998). The purpose of co-design sessions is to achieve collaboration between different groups, for example: children and adults, by designing a prototype of a common idea (Sanders & Stappers, 2008). I used the data from the co-design sessions to gather feedback and reveal insights into how teens believe that mobile interactive technologies could enhance their overall experience at a museum. Furthermore, and considering Simon's work

(Simon, 2010), the sessions held with young participants gave them a 'voice' and engaged them enthusiastically in the design process. These teens served as active participants in the technology design process (Muller, 2003; Salen, 2007), suggested as the core philosophy of participatory design, and thus were able to produce user-oriented information technologies (Taxén et al., 2004). This research complements Hall and Bannon's discussion (2005), which argues for the use of cooperative methods when designing for a museum context. Moreover, a user-driven framework is important when one is designing for a teenage audience. In fact, these findings verify that the participants were fully engaged in the creation of their ideal mobile experience for a museum context, wanting to try these experiences in situ. In agreement with Dindler and colleagues (2010), the insights gathered from these co-design activities with teens reveal some successful strategies to be developed within exhibition spaces. Judging from the variety of ideas and technologies that the participants envisaged, I propose that they would enjoy visiting museums if such experiences were made available to them.

Through mobile applications museums can engage visitors and require minimal changes to the exhibition (Bailey-Ross et al., 2016), nevertheless, not all mobile experiences would make good use of technology, as well as its delivery style, content, and graphics. There are cases in which a visitor's mental model discords with the design of the exhibition with which he or she is interacting (D. Norman, 2013), shifting the focus away from the experience and to the design itself, thereby interrupting the flow (Csikszentmihalyi, 1998) and eventually leading to frustration and poor user experiences. Therefore, learners might fail to appreciate the exhibits due to an abundance of information and the presence of time constraints that lead to information overload, or due to visitors' lack of interest in the interpretation of the exhibit (Rhee & Choi, 2015).

The findings from the studies conducted provide a strong foundation to inform and inspire work within HCI and the emerging research field concerning museums offerings and the current teenage generation. Studying teenagers' interests and needs is crucial to deploying a high-quality and enjoyable product. To achieve this, I suggest and emphasize that curators should be instructed to segment the audiences (Falk, 2009) at an early stage of their careers and also have access to design guidelines for teenage audiences, who currently constitute a challenging target.

REQUIREMENTS FOR DESIGNING MOBILE MUSEUM EXPERIENCES FOR TEENAGERS

The interests of teenagers regarding enjoyable museum tours was previous collected through Studies #1-4. Moreover, how museums and curators perceive teenagers as an audience group was also studied and reported on Studies #6-7. On the one hand, the teenagers enlightened us on the mechanics of experiences which would be appealing for them (game design elements and storytelling plots), and on the other hand, curators guided us through which kind of content and messages they would like to convey. In this section, I summarize the main findings encountered in these studies. These findings are of importance since they are distilled directly from the teenagers' minds sets and reflect their everyday engagement for the creation of joyful museum experiences that would catch their attention. These findings are listed in Table 17 as a set of 24 requirements a museum could adopt to catch the attention of teenagers, and are split into 7 topics: (i) making memories, (ii) usability & attractiveness, (iii) exploration, (iv) scientific info, (v) digital interaction, (vi) storytelling, (vii) gameplay. These topics are described in the next sections. Each requirement is refereed with a specific number from 1 to 24 that are later refereed in the sections '*requirements applied*' and '*requirements dismissed*' for the design and development of the *Memories of Carvalhal's Palace* dual experience deployed at the NHMF (next chapter), and later tested by 159 teenagers.

Table 17. *Requirements for the design of museum experiences targeted at teenagers split by topic and the studies where each requirement was found.*

Topic	Requirement	Studies
Making memories	**[RQ_01]** Share the experience on *social media* channels	Teenagers: study #3
	[RQ_02] Make memories by taking *photos and selfies* with and without AR effects	Teenagers: study #3
	[RQ_03] Relate the teenagers' *personal interests* and the exhibition itself	Teenagers: study #1 Museums: study #7
Usability & Attractiveness	**[RQ_04]** Simple *usage* of the mobile guide	Teenagers: study #2 Museums: study #7
	[RQ_05] The user interface and overall designs should be *appealing*	Museums: study #7
Exploration	**[RQ_06]** See different exhibits when taking *different digital tours*	Teenagers: study #3 Museums: study #6
	[RQ_07] Guide the visitor through the museum by using a *map* to check out points of interest and locations	Teenagers: study #3 Museums: study #6
	[RQ_08] Prompt the discovery of *unknown rooms and places* inside the museum	Museums: study #7
Scientific info	**[RQ_09]** Receive *information about the exhibits* through descriptive texts and plain images, access to their natural sounds and videos in their natural habitats	Teenagers: study #3 Museums: study #7
	[RQ_10] Display *curiosities and information about the museum* through general videos and descriptive information	Teenagers: study #3
Digital interaction	**[RQ_11]** Utilize *digital technologies* to augment the exhibits' physical information, such as *3D models*, Augmented Reality and Virtual Reality	Teenagers: studies #1, #3
	[RQ_12] Use of *location-aware technologies* for unlocking information	Teenagers: study #3
Storytelling	**[RQ_13]** Utilize *story-based* narratives to guide the experience	Museums: study #6
	[RQ_14] Base the story on an *adventurous journey*: teenagers tend to take on a leading role for themselves	Teenagers: studies #2, #4
	[RQ_15] Link an *emotional journey* within the museum: the exhibits that are part of this plot must be helped in some way by the users to generate an emotional impact	Teenagers: study #4
Gameplay	**[RQ_16]** Utilize *clues* in text and/or image format that can be combined with puzzles and questionnaires to challenge the teenage visitor	Teenagers: studies #2, #3, #4
	[RQ_17] Search for and discover exhibits through *treasure hunts* and be provided with information about the same	Teenagers: studies #2, #4
	[RQ_18] Challenge teenagers' knowledge about the exhibits through *quizzes*	Teenagers: studies #3, #4
	[RQ_19] Accomplish of in-game *achievements* through receiving points, unlocking information and increasing the level of the game	Teenagers: study #3
	[RQ_20] Utilize *collection* of pieces (of exhibits or stories) to complete a puzzle and form a bigger picture	Teenagers: studies #3, #4
	[RQ_21] Utilize *timeout strategy* to have a certain time and number of lives to visit the museum otherwise their visit will *timeout*, and the experience will finish	Teenagers: study #4
	[RQ_22] Take *action* by feeding the exhibits collected/achieved in-game	Teenagers: study #3
	[RQ_23] Play the role of exhibits showcased inside the museum and tour the exhibition from the eyes of such exhibit by utilizing *simulation/role-playing*	Teenagers: studies #3, #4
	[RQ_24] Add a digital ranking for users to check what others have done.	Teenagers: study #3 Museums: study #6

MAKING MEMORIES

This topic refers to making memories during the museum tour. Teenagers have a desire to speak, share, and actually be part of the new technologies, as they are keen on sharing their memories through **social media**. These memories could be in the form of **photos** and **selfies** with AR features. The inclusion of **connections** between teenagers' previous experiences/memories and the exhibition is positive and engaging. Technology can create personal connections between the teenage user and the information content and inspire teenagers to take a closer look.

Usability & Attractiveness

This topic refers to the usability of the mobile guide and the design of its graphics. One should be instructed to conduct **usability tests** with their target users to understand what more they can do to foster a better and more exciting experience, and be **careful** about the design that they use for deploying an experience, as teenagers do not like to be seen as children. The implementation of images and sounds must be seriously considered to ensure that it aligns with the motivations of a teenager, and not those of a child.

Exploration

This topic refers to the teenagers' exploration of the museum assisted by the mobile guide. Teenagers are interested in taking **more than one tour of the same museum and being allowed to** choose and interact with various exhibits on separate visits, and locate the exhibits in the museum via a **map**. Also, teenagers would be keen to have access to **unknown rooms and places** in the museum.

Scientific info

This topic refers to the information the museum displays to the teenage visitor. Teenagers are interested in the **museum's past history**, and seek a **general overview** of the place through informal themes rather than specific knowledge through more formal themes.

Digital interaction

This topic refers to the digital interaction encountered in the mobile experience. This generation of teens is very **fluent** in the use of new technologies and do not encounter significant difficulties in handling digital content. Teenagers wish to experience interaction through something novel. They are interested in **interacting** with exhibits through cutting-edge technologies about which they know little but that they are excited to try out. Such technologies include **location-aware technologies** (beacons, image recognition) to unlock digital content, and Augmented Reality **3D technologies** to **display models** of exhibits and allow visitors to see their details, as the exhibits themselves are locked and untouchable behind a pane of glass.

Storytelling

This topic refers to the ways in which storytelling can be used in the mobile experience. Teenagers are keen in being the protagonists of exciting **adventures**, this can be harnessed by museums to craft experiences that excite teens as well as communicate knowledge. Creating

an **emotional connection** between the visitor and specific exhibits of the museum is also valuable. Achieving an emotional reaction from teen visitors and taking them on a thrilling emotional journey can lead to their engagement with the museum experience.

GAMEPLAY

This topic refers to the application of game mechanics in the mobile museum experience. The deployment of **clues** for finding specific exhibits could enhance teenagers' museum experience as well as foster a possible increase in knowledge by allowing teenagers to solve these challenges. Obviously, some of the exhibits in the museum would have to be marked, as it is unthinkable that a visitor would view all of the hundreds of exhibits in a museum in order to find the corresponding one. Clues and escape room experiences in museums must be carefully aligned with the logic and purpose of the museum visit, as otherwise teens could be pushed through the exhibits too quickly, which would cause them to focus on finishing the visit rather than enjoying it. The application of **quizzes** is seen as a welcome strategy among teenagers, as it is meant to entice competition among visitors, as they want to be the best at their task. **Collection** is also welcomed strategy to engage teens, as after collecting pieces, they would have a bigger picture at the end. An understanding of different audiences and their motivations for collecting could inform winning strategies of encouraging visitors to engage with museums. Teenagers wish to receive a reward when they **accomplish** a task: this could be in form of receiving points, unlocking information or increasing the level of the game. This study highlights the importance of including search elements and a payoff (**treasure hunt**) in museum experiences.

Teenagers would be keen to take some digital **action** as feeding some species in the mobile experience. Teenagers would also like to experience the information presented in museums through **simulation** techniques, as they can assist museums in the creation of tours that situate the teen visitor as an active protagonist rather than as passive; the latter is what happens in most regular museum tours. **Timeout strategies** must be carefully crafted into the logic and purpose of the museum visit, as without them, teens could be pushed through the exhibits too quickly and invited to merely finish the visit rather than enjoy it. Teenagers are eager to see what others have done by viewing global **ranking** scores.

Chapter #4
USER EXPERIENCE DESIGN

This chapter shows how some of the requirements previously described were implemented via two tangible prototypes: a story-based approach (*Turning Point)* and a game-based approach (*Haunted Encounters*), both forming the *Memories of Carvalhal's Palace* (MoCP) dual experience. The aim of this implementation was to determine whether the requirements work in terms of enhancing teens' museum experience and awareness of the museum message when applied to a real-life scenario, as well as to inform guidelines for the design of mobile museum experiences through gamification and storytelling frameworks targeted at teenagers. This chapter then describes the scope of the project *Memories of Carvalhal's Palace*, the team that took part in its implementation, the process taken from early meetings with the museum to final usability tests, the requirements applied and dismissed during the designing of the prototypes, and, finally, the whole description of the two prototypes.

4.1. MEMORIES OF CARAVALHAL'S PALACE

The *Memories of Carvalhal's Palace* (MoCP) dual experience[15], was conceived and designed based on the findings and requirements identified in the previous studies and the specific context of the Natural History Museum of Funchal (NHMF). In particular, the NHMF collection comprises a large embalmed monk seal, which is one of the most endangered animals in the Atlantic Ocean. This species found shelter on Desertas Island in the Madeiran archipelago, which were finally claimed as a protected nature reserve and devoted to a monk seal sanctuary in the late 1980s. The embalmed monk seal is also one of the most important exemplars in the museum due to its size. The piece prompted us to establish a connection to the Northern European legend of Selkies in order to create characters and a mystery plot that would engage teens in learning about this endangered animal in particular and about the marine ecosystem of the archipelago in general. Selkies are said to perform therianthropy, live as seals in the sea but shed their skin to become human on land. The aim of the fictional story was to create a set of characters that would elicit emotional connection and promote awareness about the environment, especially endangered animals like seals.

Hence, based on the same museum premises and exhibits, and assisted by a team[16] of artists and researchers from the Sense&Tell research group at ITI/LARSyS, we designed the *Memories of Carvalhal's Palace* (MoCP) comprising two different interaction strategies. Rather than being radically different, the two interaction strategies use both game and storytelling techniques but at different degrees: one is game-based, centred on a game with storytelling as a background – *Haunted Encounters* (HE) – the other is story-based, centred on storytelling with elements of game mechanics – *Turning Point* (TP). The goal of developing these two experiences was to study and compare them as slightly different strategies, both taking into consideration teens' preference towards both game-based strategies and story-based strategies.

[15] The demo videos of the *Memories of Carvalhal's Palace* dual experience can be found here: https://bit.ly/2pnVyBx

[16] To note that the team had access to the previous '*requirements for designing mobile museum experiences for teenagers*' and also had access to the analysis of the study #3 – '*design patterns'* – and study #4 – '*game mechanics and narrative plots*.' However, since we are a team of artists and storytellers, we decided to develop our own story based on those requirements and examples of their usage.

4.1.2. SENSE&TELL TEAM

The Sense&Tell group belongs to the Interactive Technologies Institute, part of the Associated Laboratories of Robotics Systems (ITI/LARSyS) based at the Instituto Superior Técnico, University of Lisbon, Portugal. Currently the Sense&Tell group is based in Madeira Island, Portugal. This research group leverages on Interactive Digital Media and Human-Computer Interaction to make sense of and communicate data, impacting a wide variety of audiences. This thesis made use of several working prototypes collaboratively developed by artists, researchers and developers from the above group. The team for the design and development of the MoCP mobile apps encompassed seven people: a supervisor, a producer (myself), two 3D artists, one UI&UX designer, a unity developer and an intern for the refinement and development of the story (Fig. 31). My role as a producer was the one to initiate, coordinate and managing the team and overall creation and production of the MoCP.

Moreover, several colleagues and volunteers made various contribution to this project, which I wish to acknowledge below. António Reis: voice-over narration; Dina Dionísio: promotional actress; Tomás Nunes: story development; 'Conto Contigo' theatre, and 'Vides' Restaurant: who lend us clothes. Nevertheless, the participation of actors was also crucial for the development of such project (Fig. 32).

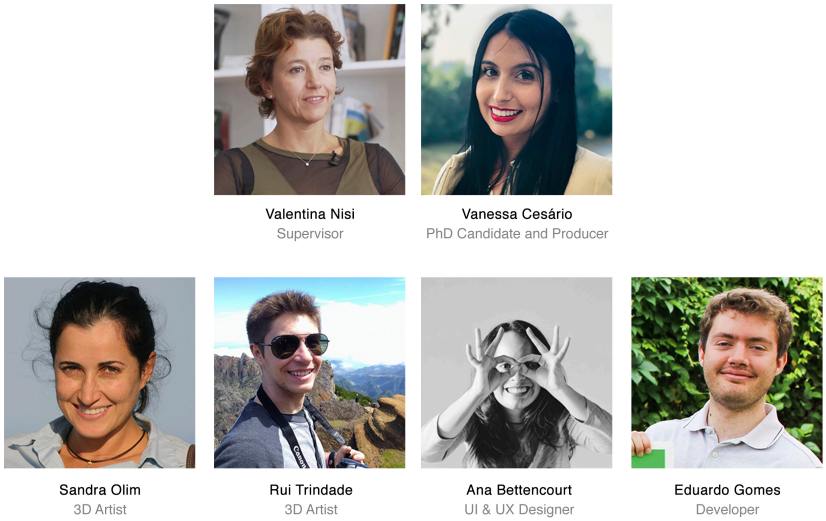


Figure 31. *Team involved in the creation and development of the 'Memories of Carvalhal's Palace' project.*

Figure 32. *Actors of the 'Memories of Carvalhal's Palace'.*

PROCESS

The creation, development and subsequently user test the prototypes in the museum involved 8 stages and took place between 2016 to 2019 (Fig. 33).

Figure 33 . *Graph resuming the process taken from the creation to the testing of the 'Memories of Carvalhal's Palace' experience.*

STAGE #1: MUSEUM

People involved: Producer, supervisor

Several meetings with the museum director were taken to understand the message and goals the museum would like to communicate to teenagers. The museum has the purpose of advising the preservation of the natural heritage of Madeira island, especially the endangered species, as well as to advertise their scientific library, the garden of aromatic plants and the history of the museum as a building. Several museum tours were also taken to understand the museum building and main species exhibited that should be addressed in the digital solution this project would create.

STAGE #2: RESEARCH

People involved: Producer

After understanding the museum goals, the next phase was to select the rooms and species that would take part of the experience, as well as researching about them to give information to the visitor through a digital solution.

The research regarding the museum building and the story script was executed with the collaboration of an intern. This 3-month interned sketched the first draft of this script.

Stage #3: Script

People involved: Producer, supervisor, 2 artists, 1 story developer

At the same time that the mobile concepts were being generated, the team adapted the story plot and characters' development to the location and context of the museum premises and insert the game mechanics and gamification aspects.

The fictional plot of the *Memories of Carvalhal's Palace – Turning Point* revolves around one of the heirs of the aristocratic Madeiran family that owned the palace, where the museum is currently located. The young heir falls in love with a Selkie woman, but she disappears in mysterious circumstances leaving him waiting at the altar. He never comes to terms with the grief caused by this loss and, as restless ghosts often do, he lingers around the museum's rooms as an angry spirit. The audience becomes aware of the ghost's drama by collecting fragments of the story that unfolds in the museum's garden. After empathizing with the fictional characters, the audience is then prompted to help them find the truth by interacting with the museum's taxidermy species.

Stage #4: Mobile Concepts

People involved: Producer, supervisor, 2 artists, 1 designer

Two big branches emerged from the studies carried: gamification and storytelling. Since the team had the time and resources to collaborate within this project, we opted to create two different mobile apps with different engagement strategies to be tested in the museum. Several meetings were held to check the best mechanics and strategies for each of the prototypes.

After having a solid idea about each prototype, low-fidelity sketches of the interfaces were developed and later refined for high-fidelity prototypes to be subsequently delivered for the technical development.

Stage #5: production

People involved: Producer, supervisor, 2 artists

Following a team decision, the production of the characters assets was based on actors photographed, and then the artists would manipulate those photographs. For this to be done, we created a green screen studio and have the actors and clothes for them to wear while being

shoot. A shooting script was created with each character and emotions they should interpret for the photographs. Then a studio was created in an empty room at ITI: we placed the green screen in a wall, as well as professional lights for photography and cameras in the room (Fig. 34). Institutions holding 18th-century clothes were contacted to lend us clothing for the shooting (Fig. 35). Then, actors were cast, and the photo-shooting initiated (Fig. 36).

Right after the shooting, the artists started manipulating the photographs and videos by creating and adding to these a watercolour effect. This effect would give the impression that the images were handmade and not digitally manipulated. At the same time, two actors were selected to do the voice-overs in the Media Innovation Lab at University of Porto (Fig. 37).

Figure 34. *Studio for the photo-shooting.*

Figure 35. *Clothes borrowed from the theatre 'Conto Contigo'. The clothes are organized for each character. Left: for Marina; Centre: for Xavier; Right: for Isabel.*

Figure 36. *Photo-shooting of the main characters: Xavier and Marina.*

Figure 37. *Voice recording at the Innovation Media Lab in Porto.*

Stage #6: Development

People involved: Producer, supervisor, developer, 1 designer

After having all the content necessary for its implementation, the developer of the team started to code the prototype functionality in Unity and incorporated the assets.

Stage #7: Usability tests

People involved: Producer, 2 artists

Since at the beginning it was not possible to make the testing in the museum due to constructions inside the institution, we opted to test the usability of the interface in the lab, to evaluate how useful and intuitive the apps were and how easy it would be for a user to reach their goals within the mobile apps. The same usability tests were then conducted inside the museum with the museum staff.

Stage #8: User testing

People involved: Producer, 4 research assistants

With fully functional mobile apps, the research study was designed and teachers from secondary schools in Madeira Island were contacted in order to agree on a schedule for their students to evaluate the mobile apps in the museum. This evaluation would be set as a school field trip of the teachers' students to the museum where students would tour the museum through the mobile apps created as well as taking part in the research study. The testing with the target audience – teenagers aged 15-19 – took finally place in 2019 for three months.

4.1.3. THE MOBILE APPS

Based on the results from the previous studies, our team selected several design patterns, game elements, and storytelling plots to embody them into two different mobile apps. These two approaches have the same background story but they do have different strategies and approaches: one centred on gaming following a non-linear approach, while other centred on storytelling following a linear-approach. I chose to have these two approaches – linear and non-linear – to check the dynamics of teenagers either using an on rails or a playful and exploratory approach.

Here I describe the mechanics and their rational related to both mobile apps, along with a briefly description of the specific differences between them. Then in the following section, I report on the requirements of teens and museum professionals derived from the studies, that were applied and dismissed by our design team.

REQUIREMENTS APPLIED

The following requirements were taken from the section "*Requirements for designing mobile museum experiences for teenagers*". Table 18 reports the requirements (15 in total) that are common to both apps and how each requirement was implemented in each mobile app. Table 19 reports the requirements that were not common to both apps (4 in total).

Table 18. *Design requirements adopted to the story-based and game-based approach.*

Topic	Requirement	Implementation
Making memories	**[RQ_01]** Share the experience on *social media* channels **[RQ_02]** Make memories by taking *photos and selfies* with and without AR effects	In *Haunted Encounters*, users are asked to take a selfie to be used as a profile picture. At the end of the experience the selfie is overlaid with the ghost character that they discovered (Fig. 57). In the end of *Turning Point*, users can take an AR augmented selfie featuring their favourite character of the story. In both apps, users can share these pictures on social media (Fig.47).
Usability & Attractiveness	**[RQ_04]** Simple *usage* of the mobile guide **[RQ_05]** The user interface and overall designs should be *appealing*	The graphics of the mobile apps were designed by professional designers and artists to have an appealing design on the theme on mystery and gaming. In both apps, a tutorial at the beginning helps users understand the game play [Appendix 24-25]. The user's actions are quite simple and involve: search for the exhibits, point the camera to an AR marker and unlock information. In *Haunted Encounters*, users unlock a 3D model of the specie, a quiz, scientific info, and a piece of a map (Figures 52-54). In *Turning Point*, users unlock a fragment of the story (Fig. 43).
Exploration	**[RQ_06]** See different exhibits when taking *different digital tours*	Users are asked to choose between two characters (Figures 41 and 48). Each character will guide the user to a different path in the museum; hence, to encounter different exhibits: one guiding through the marine animals exhibited, and the other through the land animals.
	[RQ_08] Prompt the discovery of *unknown rooms and places* inside the museum	The apps guide the visitor to discover unknown and unadvertised places in the museum, such as its garden of aromatic and medicinal plants in *Turning Point*, and its scientific library in *Haunted Encounters*.
Scientific info	**[RQ_09]** Receive *information about the exhibits* through descriptive texts and plain images, *access to their natural sounds and videos in their natural habitats	The apps provide the user with scientific information about the exhibits. In *Haunted Encounters*, this info is displayed as questions and written scientific curiosities (Fig. 52), and in *Turning Point* as voices from the characters accompanied with subtitles (Fig. 43). Both apps were built in order to give the user a general overview of the place and a selection of its exhibits. * '*access to their natural sounds and videos in their natural habitats*' was not applied.
Digital interaction	**[RQ_12]** Use of *location-aware technologies* for unlocking information	When approaching the right exhibits, users are required to use the mobile app to unlock content through Augmented Reality markers (Figures 45 and 50).
Storytelling	**[RQ_13]** Utilize *story-based* narratives to guide the experience **[RQ_14]** Base the story on an *adventurous journey*: teenagers tend to take on a leading role for themselves **[RQ_15]** Link an *emotional journey* within the museum: the exhibits that are part of this plot must be helped in some way by the users to generate an emotional impact	Users are invited to explore the museum by helping a pleading character to solve a mystery or unravel an adventurous plot (Figures 41 and 48).
Gameplay (continues in the next page)	**[RQ_16]** Utilize *clues* in text and/or image format that can be combined with puzzles to challenge the teenage visitor **[RQ_17]** Search for and discover exhibits through *treasure hunts* and be provided with information about the same	Users are provided with clues and challenged to search the exhibits throughout the museum in order to uncover a mystery. In *Haunted Encounters*, users are provided with species' shadows' images and need to search them (Fig. 49). In *Turning Point*, users are provided with the picture of exhibits in the museum (Fig. 46).

Topic	Requirement	Implementation
Gameplay (continuation from previous page)	**[RQ_19]** Accomplish of in-game *achievements* through receiving points, unlocking information and increasing the level of the game	Users receive feedback on their progression in the experience and unlock information about the exhibits. In *Haunted Encounters*, users receive points, which are displayed during the game, and tells where are they positioned in their journey (Fig. 53). In *Turning Point*, users have a timeline where, at any time, they can check where they are in the experience (Figures 44 and 46).
	[RQ_20] Utilize *collection* of pieces (of exhibits or stories) to complete a puzzle and form a bigger picture	Users are required to collect pieces to complete a puzzle and solve the mystery in which the museum is immersed. In *Haunted Encounters*, users collect pieces of a map that they will use in the end to unlock the mystery (Figures 53-56). In *Turning Point*, users collect fragments of a story to understand the story as a whole and the mystery behind it.

Table 19. *Different design requirements that were adopted by the story-based and game-based approaches separately.*

Topic	Requirement	Implementation
Exploration	**[RQ_07]** Guide the visitor through the museum by using a *map* to check out points of interest and locations	In *Turning Point,* users are displayed the images of the exhibits in their shelves that should be found to unlock info about the exhibits and the whole experience. These images are accompanied with a map of the museum indicating which room each exhibit is (Figures 40 and 46).
Scientific info	**[RQ_10]** Display *curiosities and information about the museum* through general videos and descriptive information	In *Turning Point,* the scientific info is displayed through fragments from a story crafted in a video that are unlocked in each exhibit (Fig. 43).
Digital interaction	**[RQ_11]** Utilize *digital technologies* to augment the exhibits' physical information, such as *3D models*, Augmented Reality and *Virtual Reality	In *Haunted Encounters*, after finding the right exhibit, users unlock a 3D model of the exhibit in AR (Figures 51 and 56). * '*Virtual Reality*' was not applied.
Gameplay	**[RQ_18]** Challenge teenagers' knowledge about the exhibits through *quizzes*	*Haunted Encounters* makes use of a metaphor that visitors should understand and find sense in the museum: they are provided with shadows of several exhibits that should be matched with their real exhibit in the museum (Fig. 49). After encountering an exhibit and checking its AR 3D model, users are required to challenge their knowledge through a quiz about the same exhibit (Fig. 52).

REQUIREMENTS DISMISSED

Table 20 describes the rationale behind not applying the whole requirements encountered. Our design team chose not to apply the following requirements gathered in the previous studies as our apps were intended to have simply mechanics. Hence, it would have been unthinkable to apply all the mechanics encountered on the studies conducted. However, these ones could and should be applied to other mobile museum contexts.

Table 20. *Design requirements that were not applied in the design of the mobile apps.*

Topic	Requirement	Implementation
Making memories	**[RQ_03]** Relate the teenagers' *personal interests* and the exhibition itself	As a design decision, we did not make use of this guideline as we created the story plot based on the museum's past history.
Scientific info	**[RQ_09]** Receive *information about the exhibits* through descriptive texts and plain images, *access to their natural sounds and videos in their natural habitats	* '*access to their natural sounds and videos in their natural habitats'* was not applied. This approach was dismissed as we were not able to reach this info for all of the exhibited species that take part in both mobile apps
Digital interaction	**[RQ_11]** Utilize *digital technologies* to augment the exhibits' physical information, such as *3D models*, Augmented Reality and Virtual Reality*	* '*Virtual Reality*' was not applied. It was intended to use this mechanic in *Turning Point*, in order to contrast with the AR in *Haunted Encounters*. However, due to time constrains for the development and testing of the apps, the 'VR' experience at the end was not able to be developed.
	[RQ_21] Utilize *timeout strategy* to have a certain time and number of lives to visit the museum otherwise their visit will *timeout*, and the experience will finish	We opted to not use a timeout strategy as we did not want to have teenagers rushing in the museum to end the experience and not enjoying the place as this is the opposite of the museum's goal.
	[RQ_22] Take *action* by feeding the exhibits collected/achieved in-game **[RQ_23]** Play the role of exhibits showcased inside the museum and tour the exhibition from the eyes of such exhibit by utilizing *simulation/role-playing*	To make the mobile apps as simple as possible for both development and testing stages, we opted to not add the above mechanics for having in-game shopping elements or explore the museum through simulation.
	[RQ_24] Add a digital ranking for users to check what others have done.	It was intended to use this mechanic in *Haunted Encounters*, as visitors were collecting points throughout the visit. However, due to time constrains for the development and testing of the apps, the 'ranking' option was not able to be developed.

TECHNICAL IMPLEMENTATION

Both apps from *Memories of Carvalhal's Palace* make use of the Unity3D engine, chosen for its flexibility and extensive community support. Some widely known applications that are built upon the Unity3D engine are *Pokémon GO* and *Magic Arena*. Unity3D was also chosen for being compatible with the Vuforia Engine, which provides a set of tools such as the use of custom images presented in the real world as in-game triggers, using the custom images' features for recognition (Fig. 38).

The Vuforia Engine allows the recognition of these custom images by uploading them to a database and performing a feature extraction process, determining the quality of the image as a marker for Augmented Reality during the process. This results in a black and white image with emphasis on the highest contrast points. As a rule of thumb, an image with a greater number of features provides for a better target for the AR application.

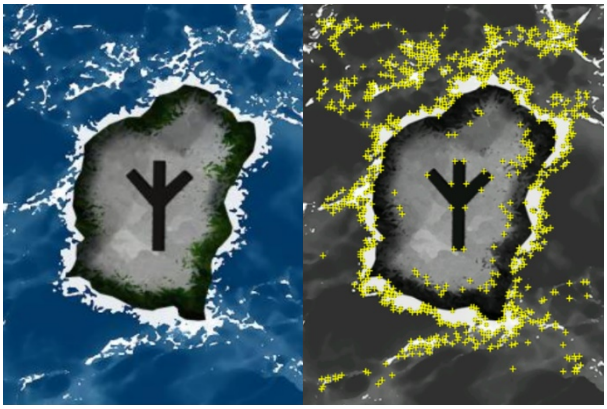


Figure 38. *Left: original market target image; Right: resulting target image with the feature points.*

In terms of *Haunted Encounters'* logic, the bulk of it is in the quiz part, where it follows the behaviour of the Factory software design pattern and builds a list of quizzes. While loading, new instances of the quiz *preset* are created and populated with the correct information relative to the displayed species. Each quiz consists of a set of questions, related to the species to which the marker is associated. To proceed, the player must select the desired species and find the correct image in the physical environment. Vuforia triggers the image recognition event, causing the application to display a question along with a set of possible answers, with a correct answer being worth full score and a wrong one only a fraction of it. Once all the questions have been answered, a new scene will load, tasking the player to find the last image. This will trigger the ending part of the application, starting the playback of videos while showing the surroundings to the player. The video format chosen was *webm*, for the support of transparency and its light-weight characteristics.

Although games typically have a fail state, the MoCP did not provide any fail state to prevent users from continuing in the gamified experience. The only 'fail' occurs when the user wrongly answers the questions in the game-based strategy *Haunted Encounters*. Although this action does not reward the user with points, the user is not prevented from continuing the activity.

4.1.4. DESCRIPTION OF THE STORY-BASED APPROACH: TURNING POINT

With the *Memories of Carvalhal's Palace – Turning Point* users are encouraged to go to specific physical locations of the museum [Appendix 20] to unlock the story plot and solve the mystery behind it. The basic mechanic relies on finding AR markers that indicate the presence of story content and unlocking story fragments that progress the plot. In this section, I describe the gameplay and mechanics of *Turning Point*.

INTERFACE

Upon starting the app (Fig. 39), the audience is presented with a tutorial [Appendix 24] indicating how to interact with the app and how to use its interface. A custom-made map (Fig. 40) of the museum will help them orient themselves in the real space and find the story content. The audience can also find out how far they have progressed into the story content according to the main timeline (Fig. 41) and where to look for markers and species in the physical premises.

NARRATION

The story is narrated through photorealistic images of the characters accompanied with dialogues rendered as voice over audios and text (Fig. 42). The user is also presented with several historical and scientific facts woven into the story, such as the existence of the Madeiran tradition of whale hunting and the inherent massacre of the seals (Fig. 43) as a threat to the old fishing industry. In the second part of the experience, which happens inside the museum, each interaction with a taxidermied species will yield scientific facts about the fauna and flora of the island together with key elements that will help the audience put together the truth behind the bride's disappearance. The story is divided into four acts, containing 16 audio visual fragments in total and is presented in the form of a gamified narrative. Its first part, unveiling the couple's drama, is structured linearly, while the second part, where the audience interacts with the taxidermied species to help the protagonists uncover the truth, is designed as five non-linear interactions each one delivering a revealing story fragment (Fig. 44).

GAME PLAY: CHOOSING STORYLINES

After the tutorial, the user is asked to choose one of the two main storylines, and follow the story from the point of one of the two main characters – the couple Xavier and Marina (Fig.

45). Depending on which one of the two they decide to follow, the events will follow a different point of view and involve different animal species in the museum.

AUGMENTED REALITY MARKERS

In order to unlock the story plot sequence, the app will guide the user through various sections of the museum, where they can find Augmented Reality markers (Fig. 46), each of which unlocks a new story fragment and is connected to a species of plant or animal [Appendix 20]. Markers can be scanned using the app.

REWARDS

Upon completing the story, the user can restart the experience and follow the other character's point of view and reinforce their knowledge of the story, while interacting with different exhibits. Care has been taken not to repeat content inside the museum, and to have the user interact with different species from those encountered through the previous experience. Furthermore, users are also rewarded with the possibility of taking a picture with the story character whose point-of-view they have experienced through the app (Fig. 47).

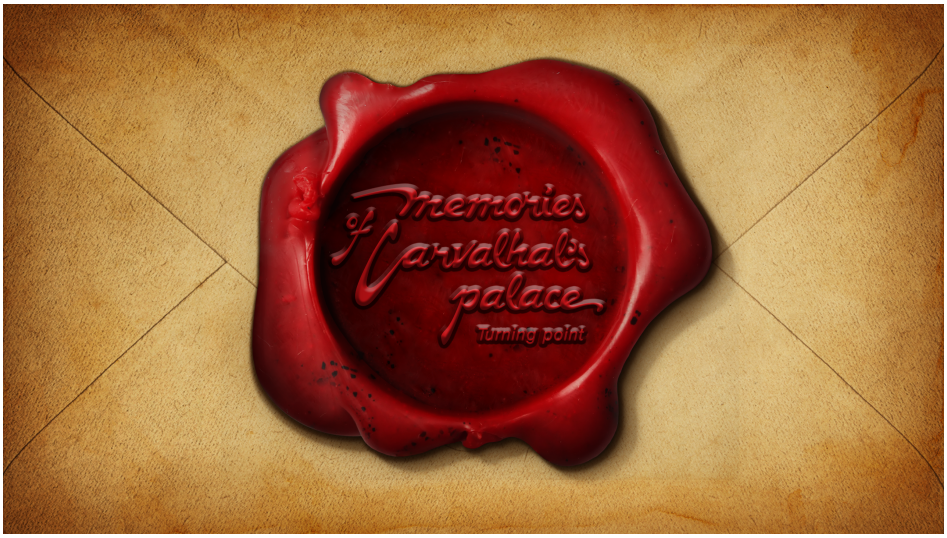


Figure 39. *Screenshot of the first frame of the intro video, launching the app Turning Point.*

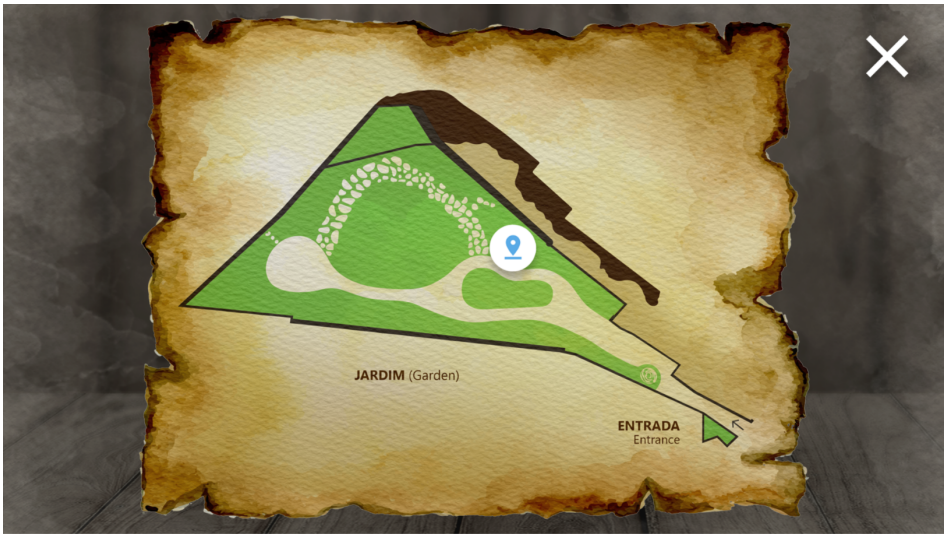


Figure 40. *Screenshot example of the map of the museum garden, and indication of the plant that needs to be found to unlock story content.*

Figure 41. *Screenshot of a clue given to the user to help them find content in the museum's garden.*

Figure 42. *Screenshot of a photorealistic rendition of a story fragment.*

Figure 43. *Taxidermied monk seal species exhibited in the NHMF.*

Figure 44. *Screenshot of the non-linear part from the app. The coloured species were already discovered and the video seen.*

Figure 45 . *Screenshot of the app when the users are invited to choose one of the characters to follow the story from their point of view.*

Figure 46 . *Example of an Augmented Reality marker.*

Figure 47. *Screenshot of the resulting selfie that the user takes with the character at the end of the experience.*

4.1.5. DESCRIPTION OF THE GAME-BASED APPROACH: HAUNTED ENCOUNTERS

The NHMF was once the residence of a noble Madeiran family, and now, according to the game backstory, some obscure forces are at play, disturbing the museum spaces. In this section, I describe the gameplay and mechanics of *Haunted Encounters*.

CALL FOR ACTION

Upon launching the app, a tutorial is displayed [Appendix 25] and then two fictional characters – Meara and Isabel – ask the user for help (Fig. 48). Depending on which character the players choose to help, two different museum tours and game endings are delivered [Appendix 23]. Meara leads the player to explore the marine species collection of the museum, while Isabel leads them to get to know the terrestrial fauna.

GAME OF SHADOWS

To uncover the truth about the haunting of the museum the players need to interact with the species in display on the glass shelves. The players engage in a game of shadows (Fig. 49), where they have to match museum exhibits with the silhouettes proposed by the application screen, one at the time.

MARKERS AND AUGMENTED REALITY EXHIBITS

Since not all the species in display are part of the game, special markers, designed in the shape of Runes (ancient Nordic divining alphabet) contradistinguish the species that are part of the game [Appendix 21]. When the users find the animal that they recon corresponds to the shadow displayed on the app, they can capture the Rune shaped marker (Fig. 50). Each rune corresponds to a letter and a specific sound. Although Norse cultures later adopted the Latin alphabet, they maintain the runes in their cultures attributing to them a deeper hidden meaning often, as the word "rune" itself means "secret", or "something hidden". The runes would be often engraved in stone, wood, or bone and were used as charms and each one of them got attributed a charmed value, such as "Protection", "Adventure", "Strength", etc... Each rune attached to the exhibits taking part in the game has a meaning especially related to each of the exhibits attached.

AR 3D MODELS – FREEING SPECIES FROM THE GLASS SHELVES

By identifying the correct species from its shadow, the players unlock a corresponding AR 3D model (Fig. 51), which they can explore in detail by manipulating the 3D model on the mobile screen. They can rotate the model in all directions, complementing the knowledge and the experience gained from observing the exemplar in the glass shelves.

QUIZ

After capturing the marker and the corresponding AR 3D model, the app requests the audience to answer a quiz related to the animal in the shelves. This is a question which requires the user to look closely at the exhibited species, as the question is related to an aspect of its physical details. After answering the question, correct or incorrectly, the audience is presented with a text reporting on several scientific facts about the animal (Fig. 52).

THE PUZZLE AND THE TREASURE-HUNT MECHANISM

For every completed interaction, from finding the silhouettes' corresponding animal, to receiving the scientific information, the audience is rewarded with a piece of a puzzle, representing a map. (Fig. 53) Once completed, the map will guide the players to a hidden location, the scientific library of the museum. In the library, the audience is asked to look for a small chest, containing the answer to their search for the truth. The chest can be found among the scientific publications of the library. Opening the chest reveals a final marker (Fig. 54), which will present them with one of the two potentially different endings, depending which character they decided to help at the beginning (Fig. 55). One character will lead the audience to discover a ghost (Fig. 56), who has been haunting the museum for almost a century while the other will menace the players herself with a malignant turn of events.

THE REWARD – A TOKEN FOR LATER REFLECTION

In the end, regardless of whom they have been helping, all players receive a reward for finishing their quest. They can take a selfie photograph with the specific ghost or malignant spirit they encountered, which will be emailed to them along with their game score (Fig. 57). Moreover, they will receive a book (in a printable PDF format) containing pictures and scientific facts of the animals they engaged with during the tour (Fig. 58). The book also contains the Rune markers which can be recaptured at any time to release the AR 3D models of the species.

Figure 48. *Left) Splash screen opening the app Memories of Carvalhal's Palace – Haunted Encounters. Right) Screenshot of the two main characters who call the player to take action.*

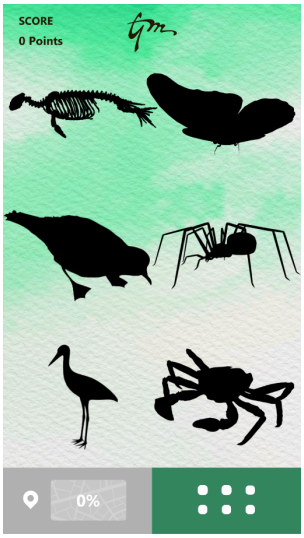


Figure 49 . *Screenshot of the app game of shadows' interface.*

Figure 50. *Rune marker used to unlock the 3D model of the Butterfly. In this game, each rune is related to a different exhibit. This specific rune is related to the Butterfly as this one means "change".*

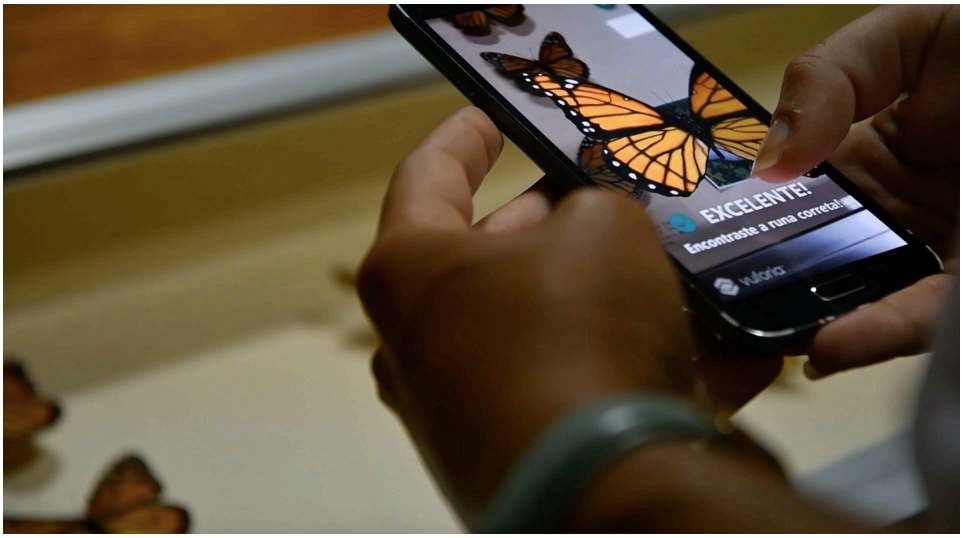


Figure 51 . *User interacting with the 3D model of the Pufferfish displayed as Augmented Reality.*

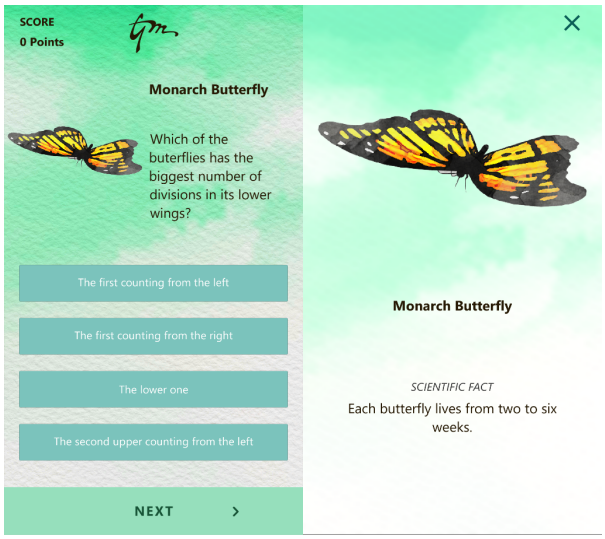


Figure 52. *Screenshot of the app: on the left, question related to the exhibit; on the right, scientific facts about the species.*

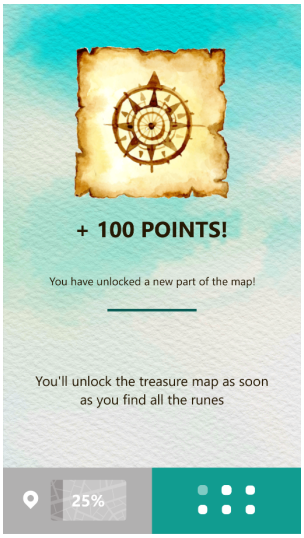


Figure 53. *Screenshot of a piece of map unlocked after finding the right rune.*

Figure 54. *User finding the last Rune inside the treasure box.*

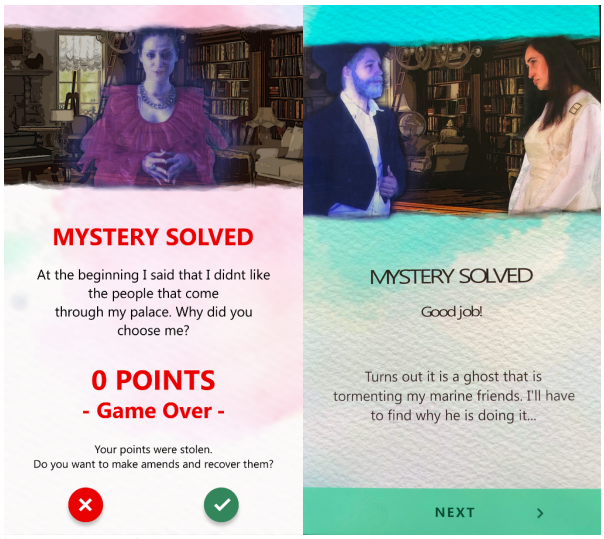


Figure 55 . *Screenshot of the ending of the game according to the two characters Isabel, (left) and Meara (right).*

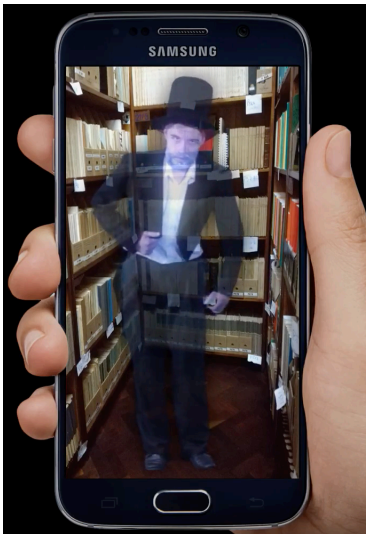


Figure 56 . *Ghost from Meara's storyline.*

Figure 57 . *Screenshot of the selfie photograph with the Isabel's malignant spirit the user encountered, which will be emailed to Maria – the user – along with her game score.*

Figure 58. *Two pages inside the Digital book rewards.*

Chapter #5
VALIDATION: EVALUATION OF THE USER EXPERIENCE

This chapter describes the research study design and results of the evaluation of the two mobile applications by 159 teenagers, the story-based approach (*Turning Point* – TP) and the game-based one (*Haunted Encounters* – HE).

5.1. RESEARCH STUDY

To answer the research questions reported in Chapter #1, both MoCP approaches were tested with a large sample of teenagers to determine whether those requirements worked when applied to a real-life scenario. This study involved one museum, five researchers, ten smartphones (Samsung 5, 6, 7, 7S). In this chapter, I describe the design of the study and its results.

THE STUDY DESIGN

Each group of participants experienced one mobile app[17]: either *Haunted Encounters* or *Turning Point*. During the experiment, the smartphones used by each group of participants (containing two people) recorded their conversations, which were later transcribed to find patterns of attitudes within the mobile museum tour. From these recordings, we were able to understand how teenagers perceive the impact of using two different mobile approaches, through their informal chats regarding this matter. During the tour, two researchers were in the museum in the event that someone needed technical help.

Upon the completion of the mobile tour, the participants were briefly interviewed in their groups as they arrived in this room in order to give us fast qualitative feedback. The interview was audio recorded. The following topics were addressed: (i) general comments; (ii) the best features; (iii) the worst features; (iv) improvements to apply; (v) awareness – what they remembered about the whole exhibition.

Then, participants were invited to fill questionnaires in order to gather information about the users' engagement with the exhibition, the game experience, and the usability of the mobile app. Participants were told that such activity would take a maximum of 15 min. The questionnaires were first verbally introduced by the researcher, and each participant answered it alone, not in groups. The questionnaires were the following:

1) Museum Experience Scale (MES) (Othman et al., 2011) [Appendix 14]. The MES measures a visitor's overall experience in museums, particularly the engagement with the exhibition. This scale has 4 components: 1) the engagement with the exhibitions and exhibits; 2) the knowledge/learning gained from the exhibition and exhibits; 3) the meaningful

[17] For this evaluation, I decided not to compare the MoCP dual experience with any non-digital gamified experience, due to time constrains for the development of a non-digital approach. Still, a comparison between digital and non-digital gamified museum experiences is an interesting research topic.

experiences from the interaction with the exhibitions/exhibits and/or other visitors, and 4) the emotional connection with the exhibits/exhibitions. Each component contains 5 questions each.

2) Multimedia Guide Scale (MGS) (Othman et al., 2011) [Appendix 15]. The MGS measures reactions to the usefulness and usability of mobile guides. This scale has 17 questions within 3 components: 1) the general usability of the mobile; 2) learnability and control, and 3) the quality of interaction with the mobile.

3) Game Experience Questionnaire (GEQ) (Poels et al., 2007) [Appendix 31] – the post-game module: This scale measures reactions after once a player has stopped gaming. It captures the playing experience based on 4 components with a total of 17 questions: 1) the overall positive experience; and 2) negative experience; 3) tiredness; and 4) returning to reality.

On one hand, by applying both the MES and Game Experience Questionnaire, I would be able to understand how teens perceive and feel connected with the digital museum tours. On another hand, by applying the MGS, participants would report on the usability problems encountered. These quantitative measures can helpfully complement qualitative information about visitor experience through their voice recordings and interviews.

SAMPLE

The study was conducted with 159 teenagers (77 females, 82 males) from several schools in Funchal, aged between 15-19 years old. Participation to visit the museum and being part of the study was voluntary. Parents and legal tutors signed consent forms on behalf of their children to take part in the study, as they were to tour the museum as part of a school field trips with their class and teachers [Appendix 26]. Teachers had demonstrated interest in showing new modes of mobile museum interaction to their pupils. After obtaining the above permissions for being part of the study and audio recorded throughout the experience, I schedule 2-hour time slot for each class of 15/25 students.

PROCEDURE

INTRODUCTION & COORDINATION OF GROUPS

All the participants were welcomed in the hall of the museum and were introduced to the experience (mobile tour + questionnaires at the end) which would have a maximum of two hours; the participants paired with a partner of their choosing; each pair would receive a mobile phone with one of the two apps randomly assigned; two pairs, one per version, were starting their experience in the museum every 5-10 minutes as to avoid pairs with the same app crossing paths at the same time. Since the user should scan a specific code (runes) to unlock digital

information, and since there were two versions of the mobile app for testing, I wanted to avoid to have all the participants starting to scan the same code in the same exhibit at the same. The time gap was very short and allowed the different pairs engaging with each other during the tour, after having scanned the first codes. Moreover, the museum was closed to the public and dedicated solely to the study. While waiting to start or after they finished, participants were free to visit the Aquarium and a temporary exhibition that were not part of the study. In this hall, there was always a researcher in charge of:

1) Distribution of numbered labels. Distribution of sticky numbered labels that participants should stick on their clothes for being identifiable by researchers.

2) Setting up the audio recording & mobile experience. Switch on all the smartphones and audio recording through the app 'Voice Recorder' and then the mobile app for testing. The 'Voice Recorder' should be running in the background as the same time that the mobile app. Participants knew they would be audio recorded throughout the tour, however they did not know in which specific moments the recording could occur. I chose to record them throughout the tour as the research team will not be able to observe and take notes about the chats of the whole participants. With these recordings, we should be able to understand their attitudes with the tour, each other, the mobile app, as well as to catch their opinions on the tour while having personal conversations. Moreover, it would be interesting to understand if they were talking about the exhibition, or the museum, or usability issues with the mobile, or other subjects, or even if they were running to be the fasted or slowing down to enjoy the exhibition.

2) Setting up the groups. Give one smartphone per each group of two people (Fig. 59) with a different version of the mobile app (marine or land animals).

3) Taking notes. Notes on which mobile version and exact time each group leaves the room.

4) Setting up the time gap. Each two pairs, with different versions of the same app, would start the tour with a time gap of 5/10minutes as to avoid pairs with the same app crossing paths at the same time. However, there were times where several pairs encountered other pairs, but were not at the same species at the same time. The 10 mobiles used in the study allowed us to have a continuous flow of 20 people visiting at the same time.

Figure 59. *User testing: a group checking the curiosities of the Bird through the Haunted Encounters' mobile app.*

USER TESTING & OBSERVATION

During the user testing, two observers would follow and shadowing random groups and fill an observation sheet [Appendixes 27-30]. These participants knew they were being followed, but the observers were distant and only talked with them if they asked for any help. Each observer would:

1) Follow random groups. One group that is being followed finishes the tour, each observer will start a new observation with another group leaving the hall to start the experience.

2) Be assigned with one version. Each observer was assigned with one version of the app and should only follow the groups who would perform that version. With this decision, each observer would exactly know where the exhibits of their version were placed and help the observant if they asked.

3) Fill an observation sheet. Each observer will fill an observation sheet regarding the trajectory of each group, draw the path of the group throughout the museum.

4) Take the smartphone and follow a new group. At the end, the observer should take the smartphone of the group from the last spot in the museum to the hall, deliver to the researcher in that spot, pick the next participants, and follow them with a new Observation Sheet.

LAST SPOT & CONCLUSION

Another researcher was placed in the last spot of the museum experience and had the following tasks:

1) Take notes. Take note of the exact time each group finishes the experience, for later knowing how much time each group took to finish the mobile tour.

2) Smartphones & Audio recorder. Keep the smartphones, save the audio file that was running in background.

After the experiment, the participants were instructed to go to a specific room in the museum with me to give a short interview about their experience and answer questionnaires (MES, MGS, GEQ). In the interview, the following topics were addressed: (i) general comments; (ii) the best features; (iii) the worst features; (iv) improvements to apply; (v) awareness – what they remembered about the whole exhibition.

DATA ANALYSIS

The data was analysed according to two different topics: 1) types of teenage visitors (recordings); 2) differences between *Turning Point* and *Haunted Encounters* (interviews and post-questionnaires). The data analysis is described in the next sections.

TYPES OF TEENAGE VISITORS

For this analysis, I focused on the attitudes of the participants throughout the mobile tour. To this end, all the suitable recordings, interviews and paths were transcribed in order to check the dynamics of each pair. From the sample of 159 teenagers, I excluded from this analysis the following ones: (i) the ones who were not recorded during the tour (59 people); (ii) the ones who were recorded during the tour but did it alone (4 people); (iii) the ones whose recording was imperceptible (18 people). I ended up with 78 people analysed under the analysis described above (46 females, 32 males, average age of 16.62).

STORY-BASED VS GAME-BASED

All of the 159 participants were interviewed and answered the post-questionnaires at the end of the experiment, hence, all participants were considered for this analysis. The aim of this analysis was to understand which mechanics of each mobile approach were preferred or hated by the participants in order to understand what would engage them the most in a natural history museum mobile tour.

5.2. APPROACH #1: TYPES OF TEENAGE VISITORS

ANALYSIS

Independently of the experience strategy they had (story or game-based) I coded the teens' attitudes through thematic analysis (Braun & Clarke, 2006). Firstly, all the suitable recordings and interviews were transcribed in order to check the dynamics of each pair, and also to verify their "ludic literacy" (having the vocabulary to be able to talk about experiencing gamified experiences in parallel with emotions). Secondly, the recordings and interviews were paired and put together in a single word document regarding each pair of users. Thirdly, I familiarize myself with the data of each pair via multiple readings to identify the main topics participants were talking about, and defined codes that could describe the content. A code is a description, not an interpretation. Codes across the whole set were then collated into subthemes and a further cluster of broader themes was defined at the higher level (Table 21). While codes identify interesting phenomena in the data, themes are interpretations of the codes and the data. Themes were refined to identify visitor types regarding participants' attitudes, and given clear names and definitions to capture the essence of each one.

The paths of each group, previously drawn by the observers, were digitalized and grouped by the types of visitors generated to verify if there was any difference in their paths throughout the museum. Unfortunately, for lack of resources, not all the groups were observed, therefore, the maps generated do not cover all the groups allocated to each type of visitor.

Table 21. Map of the themes generated from the participants' voice recordings and interviews.

TYPE OF VISITOR	THEME	SUBTHEME	CODE
GAMERS	Mobile App	Mechanics	Tour the museum just through the gamified experience – interested in the mechanics
	Challenge	Win	Be claimed the winner
	Self-judgment	The best	Being the fastest and the best, willing to be better than others
GAMERS COMPETITIORS	Mobile app	Excitement	Excitement for the hunt
	Speed	Walking	Walk very fast throughout the museum
	Challenge	Progression: enjoyment (against others)	Focus on progression and achievements (compete against others)
		Progression: annoyed	Blame others because of points lost
		Competition: double check	Competitive attitude: check if the answers is correct
		Competition: thundering	Obliterate the competition
GAMERS SKIPPERS	Story	Skip	Skip story fragments
EXPLORERS	Mobile app	Understanding	Understand how it works
		Curiosity	Curiosity and amusement for details
	Exploration	Careful	Explore the museum carefully to see the exhibits
		Curiosity	Curious to find more about the exhibition
		Past experiences	Talk about and the exhibits relate with their past experiences
		Positive expressions	Express positive expressions throughout the museum tour with
	Speed	Walking	Do not run around the museum
	Story	Skip	Skip story fragments
	Challenge	Neutral	Winning or losing does not really matter, and are not concerned about others
EXPLORERS ADVENTUROUS	Exploration	Fun	Have fun exploring
		Other exhibits	Look at other exhibits not approached in the mobile experience
		Social	Share out loud their feelings about the experience
	Story	Listen	Listen and are interested in the story
		Interested	Play for the story and thrilled of the gamified experience
		Intrigued by the plot	Intrigued by the plot: drama and characters
EXPLORERS ACHIEVERS	Exploration	See everything	See as much as there is to see
	Challenge	Progression: enjoyment (not against others)	Happiness for progression achieved, willing to improve (not against others)
		Progression: fun	Complete the experience to have fun
FOLLOWERS	Mobile app	Excitement	Excitement for the hunt
	Exploration	Careful	Explore the museum carefully to see the exhibits
		Past experiences	Talk about and the exhibits relate with their past experiences
		Social	Share out loud their feelings about the experience
	Story	Listen	Listen and are interested in the story
		Intrigued by the plot	Intrigued by the plot: drama and characters
		Do not skip	Do not skip the story fragments, follow it carefully, excitement and happiness in finding a new fragment
UNCOMFORTABLE	Mobile app	Technology	Focused on the technology rather than the experience itself: not giving importance to the tutorial
	Exploration	Other exhibits	Look at other exhibits not approached in the mobile experience
	Challenge	Luck	Lucky games to guess the right answer
	Self-judgement	The worst	Not knowing anything and feeling guilty throughout the tour
		Lost	Wondering if they are taking the right path, unsure if they are doing the right thing
		Others	Concerned about what others might of them, worried about not being as good as others
		Feedback	Looking for feedback and recognition, wanting successfully pursue the tour

RESULTS

This section describes the results of the 'Types of teenage visitors' generated, and the paths from these visitors throughout the museum.

After analysing the data for each pair of teenagers (recordings, interviews), I focused on the relationship between the pair of users and the museum (types of visitors), and the relationship between the teenagers of a pair (categories). I come up with six types of teenage visitors, describing their basic needs and motivations. Each pair of teenage visitors falls into one of the six types of museum visitors: *gamers-competitors, gamers-skippers, explorers-achievers, explorers-adventurous, followers or uncomfortable*. Then, each type of museum visitors falls into one of the two categories: *lovebirds*, or *frenemies* (Table 22).

I begin first with the description of the relationship between the two teenagers in a pair. After describing these categories (*lovebirds* or *frenemies*), I describe the types of visitor and their relationship with the museum mobile strategy (*gamers-competitors*, *gamers-skippers*, *explorers-achievers, explorers-adventures, followers or uncomfortable*), giving examples how these types of visitors are applied to the different categories (*lovebirds* or *frenemies*). Figures 60 and 61 show the samples split by type of visitor and these split by their categories.

Table 22. *Total of male and female participants split by the types and categories of participants from the proposed classification on Teenage Visitor Experience.*

Type / Category	Turning Point				Haunted Encounters				Total (number)	Total (%)
	frenemies		lovebirds		frenemies		lovebirds			
	F	M	F	M	F	M	F	M		
Competitors	0	0	0	0	0	4	0	0	4	5%
Skippers	0	0	0	4	0	0	0	0	4	5%
Achievers	0	2	0	2	3	3	5	3	18	23%
Adventurous	6	2	3	3	5	1	7	5	32	41%
Followers	0	2	8	0	0	0	0	0	10	13%
Uncomfortable	0	0	0	0	4	0	5	1	10	13%
Total	6	6	11	9	12	8	17	9	78	100%

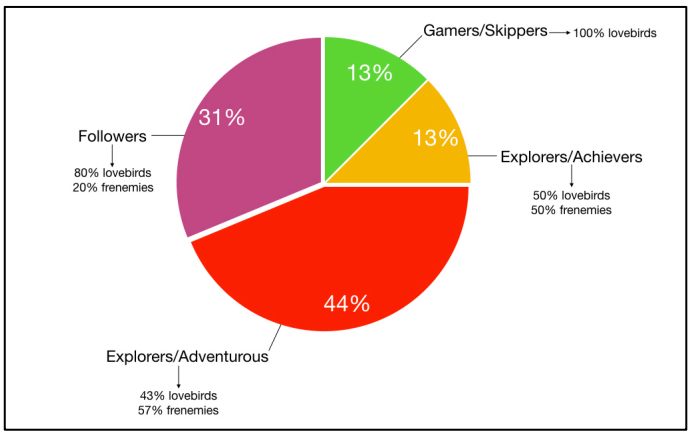


Figure 60. *Types and categories of visitors encountered in the 32 people who tested the story-based 'Turning Point'.*

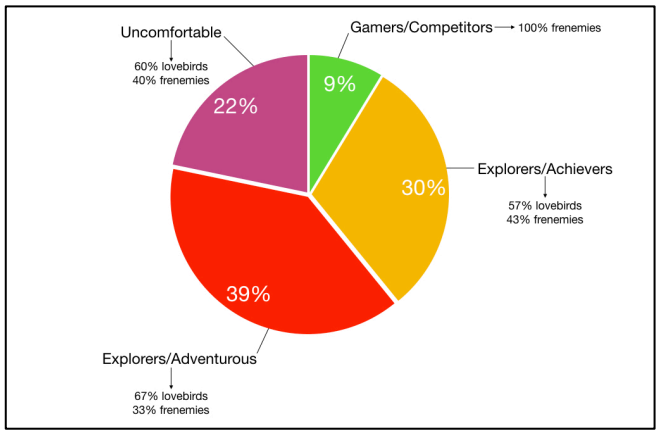


Figure 61. *Types and categories of visitors encountered in the 46 people who tested the game-based 'Haunted Encounters'.*

CATEGORIES: ATTITUDES BETWEEN THE TEENAGERS OF A PAIR

LOVEBIRDS

Pairs categorised as *lovebirds* are always together and do not display any significant disagreement. They rely on and help each other as they have the same purpose. In some cases, the relationship can be hierarchical, there is a leader and a follower – one dominates and leads while the other is satisfied by following, or collaborative – accomplishing what has been agreed, strongly cooperating to achieve the goal that has been set for them. One usually handles the smartphone, manages and provides the tasks the pair should follow to complete the journey successfully.

FRENEMIES

Pairs categorised as *frenemies* are friends and enemies at the same time. Their relationship is one of equals, cooperation or negotiation (friends) but at times it has elements of confrontation or competition (enemies). They often discuss which decisions to take – each one presenting motivations. Sometimes one could be more determined than the other to complete the tour in the shortest time while the companion prefers to enjoy the exhibition for longer. Moreover, they could have different opinions about the location of the exhibit they have to find, which generates disagreements.

TYPES OF VISITOR: TEENAGERS' BEHAVIOUR WITH THE MOBILE STRATEGY AND THE MUSEUM

This section describes in detail the types of visitor. Each description of the type of visitor is accompanied by a map of their path in the museum. Not every visitor was observed, hence there are cases where the number of visitors observed is not equal to the total of visitors who were audio-recorded (Table 23).

Table 23. *Total of visitors observed and non-observed in each type and in each mobile app.*

App	Type	Avg. Time	Observed	Non-Observed	Total
Story-based (TP)	Gamers-Skippers	29m	4	0	4
Game-based (HE)	Gamers-Competitors	12m	0	4	4
Story-based (TP)	Explorers-Achievers	32m	2	2	4
Game-based (HE)	Explorers-Achievers	13.14m	10	4	14
Story-based (TP)	Explorers-Adventurous	33.14m	6	8	14
Game-based (HE)	Explorers-Adventurous	14.11m	14	4	18
Story-based (TP)	Followers	39.60m	2	8	10
Game-based (HE)	Uncomfortable	14.60m	6	4	10

GAMERS

Gamers are motivated in pursuing the mobile experience in the museum to win and be the best, even if it is not a competition. They are not interested in the story but only in its mechanics. Hence, they explore the museum only through the app, which is more important to them than looking at the exhibits in the exhibition. Their primary objective is to complete the tour. *Gamers* are *Competitors* if involved through the game strategy or *Skippers* with the story (percentages in Figures 60-61).

Gamers-Competitors (occur only in the game-based strategy HE) approach the digital tour with a competitive attitude to complete the experience. If it can be beaten, they want to beat it; if it can be answered, they want to answer it; if it can be collected, they want to collect it. They are not easy to manage they cheat and cannot be trusted. As long as they can obliterate the competition, they are happy: they will do anything in the real world for others to be worse than them, such as closing doors, hiding items or do not give any help that others might ask. Although they say they like exploring the museum, excited about finding exhibits, they are focused on achievement and progression, and concerned with having more points than their classmates. They hesitate with the challenges they need to take, because they want to answer correctly and achieve perfection. Moreover, they feel very sorry and annoyed if they answer incorrectly because they lose points. They also hesitate to ask for help as not to lose either points or time. However, they do not hesitate in searching all the museum to find the right answer. *Competitors* often fall into the *frenemies* category. Most of the times, one person

frequently blames the other about points lost and wrong answers, sometimes they hold a grudge throughout the tour. Even when the visit is over, they kept on expressing how annoyed they were about these issues.

Gamers-Skippers (occur only in the story-based strategy TP), often skip the narrative in the story fragments, pursuing a fast ending of the experience in order to distinguish themselves in being the first. The story plot does not engage them, nor the characters drama or their transformation. They are not interested in the exhibits, only in getting there first or being better that the others somehow. It seems they have mistaken the story for a game. As seen in their path (Fig. 62), they almost never stop to see other exhibits. They usually use expressions such as: "*Let's be the fastest ones!*" "*Skip, skip, skip. Let's go!"* This type of visitor often falls into the category *lovebirds*. Most of the times, both have the same interest in skipping the story, without any disagreements.

Figure 62. *Path from the 'Gamers-Skippers' visitors observed in the museum with the story-based strategy 'Turning Point'. The different colours of the numbered dots and lines correspond to the different versions of the app. The numbered dots correspond to the species in game visitors should encounter in their version. The dots without a number correspond to the stops visitors made in the museum to see other exhibits.*

EXPLORERS

Explorers are good learners and take time to understand how the experience works. They are curious and can be amazed by details – in both the apps strategies and towards the museum. They express positive thoughts throughout the visit such as "*this is beautiful*". They take time to explore the museum carefully as they want to experience the exhibits and the museum in details. Usually when they find the exhibit the app is pointing to, they want to know more about it: they carefully read the curiosities in the app and the label on the exhibition, look at their virtual images and the real exhibit on display, or comment on how the exhibit relate to their past experiences. To them, winning or losing in the game does not really matter, as they are in it to have fun, learn and explore. However, for them the story plot or game mechanics are secondary. *Explorers* are split into two strands: *Achievers* and *Adventurous* with both categories occurring in both strategies (percentages in Figures 60-61).

Explorers-Achievers try to see as much as there is to see in the exhibition, complete the experience and have fun at the same time. They want to do well and achieve the pre-set goals, but do not see themselves as competing against their colleagues. As seen in their path (Figures 63-64), *Explorers-Achievers* during the game-based strategy HE make an effort to explore the museum in search of the right exhibits being very unlikely to stop to check other exhibits; while in *Turning Point*, they stopped near other exhibits not part of the experience.

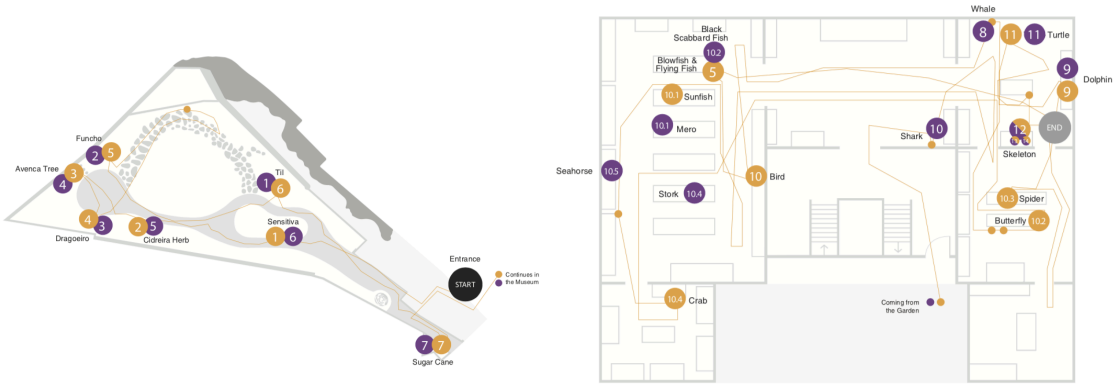


Figure 63. *Path from the 'Explorers-Achievers' visitors observed in the museum with the story-based startegy 'Turning Point'. The different colours of the numbered dots and lines correspond to the different versions of the app. The numbered dots correspond to the species in game visitors should encounter in their version. The dots without a number correspond to the stops visitors made in the museum to see other exhibits.*

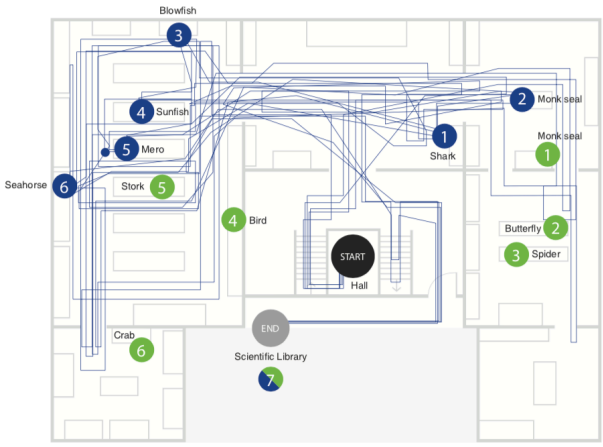


Figure 64. *Path from the 'Explorers-Achievers' visitors observed in the museum with the game-based strategy 'Haunted Encounters'. The different colours of the numbered dots and lines correspond to the different versions of the app. The numbered dots correspond to the species in game visitors should encounter in their version. The dots without a number correspond to the stops visitors made in the museum to see other exhibits.*

Explorers-Adventurous use the tour to have fun and enjoy the original museum visit, afforded by the apps. They love to play and are thrilled by the gamified experience, they are taken by the compelling story, and amazed by the exhibits. Often, they are excited by and interested in exhibits that are not part of the tour. Although they skip some of the fragments, they are interested in the overall story, and share their feelings and assumptions about the whole plot. As seen in their paths (Figures 65-66), *Explorers-Adventurous* explore the museum in both apps. However, through these paths, we can see that they explore the museum more during the game-based strategy HE than during the story-based TP, as in the game-based strategy they stopped more near exhibits not part of the experience. Also, during this last one, they just explore the garden through the mobile, not stopping in any other plants.

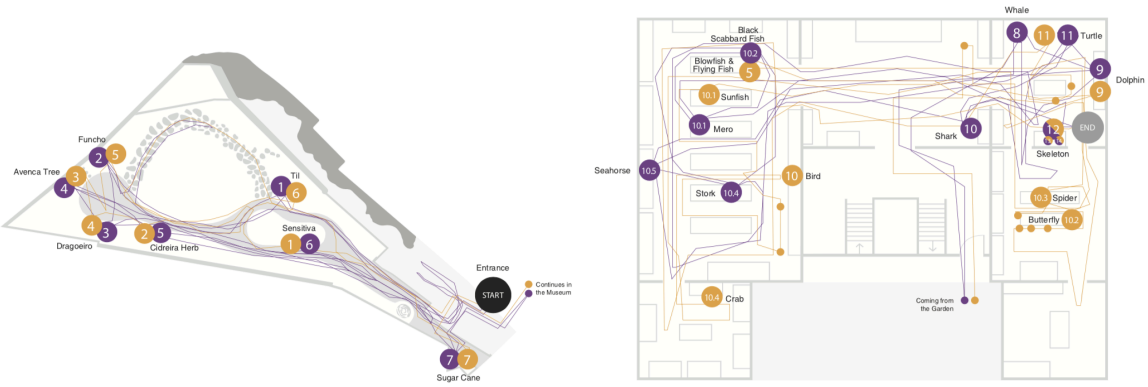


Figure 65. *Path from the 'Explorers-Adventurous' visitors observed in the museum with the story-based strategy 'Turning Point'. The different colours of the numbered dots and lines correspond to the different versions of the app. The numbered dots correspond to the species in game visitors should encounter in their version. The dots without a number correspond to the stops visitors made in the museum to see other exhibits.*

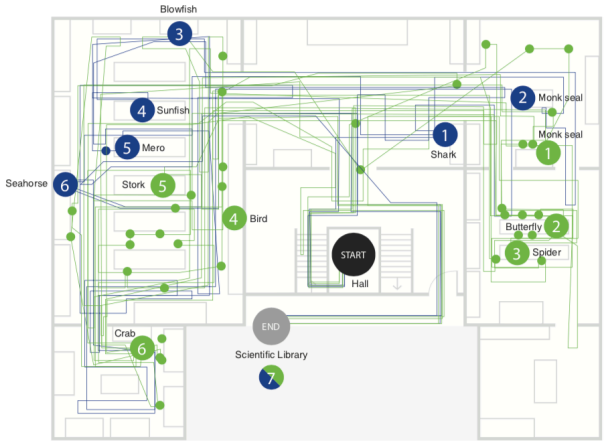


Figure 66. *Path from the 'Explorers-Adventurous' visitors observed in the museum with the game-based strategy 'Haunted Encounters'. The different colours of the numbered dots and lines correspond to the different versions of the app. The numbered dots correspond to the species in game visitors should encounter in their version. The dots without a number correspond to the stops visitors made in the museum to see other exhibits.*

Explorers fall into both categories: *lovebirds*, and *frenemies* (percentages in Figures 60-61). If *loverbirds*, they are both enthusiastic about the museum tour and cooperate to get most out of the experience. If one is more enthusiastic than the other, the other will usually follow and cooperate in the strategy. However, if *frenemies*, several kinds of arguments can arise. One could blame the other for not helping enough, or distracting from exploring the museum properly. Conversely, they can argue if one wants to listen to the story and enjoy the exhibition, while the other wants to finish in the shortest possible time, or if they have different opinions about the location of the exhibit they have to find.

FOLLOWERS

Followers (occur only in the story-based strategy TP) are willing to listen and take in the full story as they are intrigued by its plot: this type of visitor displays the participants with an inherent interest in stories. They follow it carefully and do not skip any fragment. For *followers*, collecting these story fragments is a quest, and it is mostly associated with positive emotions. There is happiness in finding a new story fragment, excitement in the hunt, social connection when sharing out loud their findings and worries about the plot. While exploring the museum, by looking and appreciating its premises, *followers* tend to talk about the species encountered and relate them to their past experiences. From their path (Fig. 67), *Followers* explore more the inside of the museum than its garden. In the museum, they stopped to check other exhibits, while they just stopped in the garden to check the exhibits the story proposed.

Followers fall more into *lovebirds* (80%) than *frenemies* (20%) categories (percentages in Figures 60-61). If they are working together and both enthusiastic about the story, they will both help each other to get the most out of the experience (*lovebirds*). However, they could have different opinions about the location of a specific exhibit they have to find to follow the story (*frenemies*). Sometimes one could be more willing than the other to find these locations pushing to walk faster across the museum, while the other would like to walk slowly to look at the display (*frenemies*).

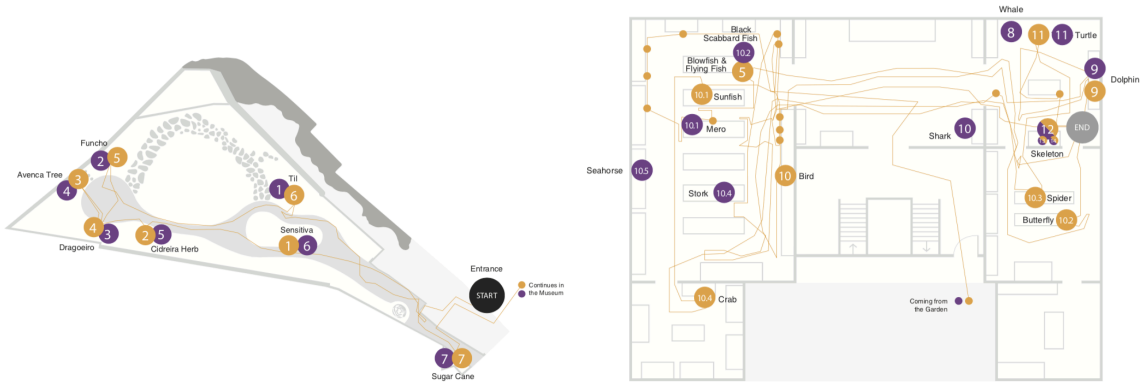


Figure 67. *Path from the 'Followers' visitors observed in the museum with the story-based strategy 'Turning Point'. The different colours of the numbered dots and lines correspond to the different versions of the app. The numbered dots correspond to the species in game visitors should encounter in their version. The dots without a number correspond to the stops visitors made in the museum to see other exhibits.*

UNCOMFORTABLE

Uncomfortable participants (occurred only in the game-based strategy HE) are worried about their performance, more than anything else. They are anxious about the use of the technology but often overlooking the tutorial and the introductions provided at the start of the tour. These visitors are more concerned about the other colleagues than the experience itself; they are worried about not being as good as their classmates in understanding the technology. When stumbling across a difficult challenge (quiz or other), they ponder what the right solution might be and often rely on luck to get the right answer. They see luck as the fast way to answer what they do not know as they are keen to finish the tour quickly to avoid being the last ones. They often find themselves lost in the museum, questioning if they are taking the right path, and unsure if they are doing the right thing. These visitors tend to feel inadequate throughout the tour, always judging themselves as "*we do not know anything*" and "*we are awful*". Sometimes their attention is captured by other exhibits that are not part of the proposed mobile tour. As seen in their path (Fig. 68), *Uncomfortable* also explore the museum by checking other exhibits not part of the game.

This type of visitor either falls into *lovebirds* (60%) or *frenemies* (40%) categories. (percentages in Figures 60-61). Both in a pair can be shy, and no one takes the leadership; or one could assume the control of the tour while the other helps (*lovebirds*). However, sometimes they could have different opinions about the location of a specific exhibit, and one blames the other about choosing the wrong location (*frenemies*).

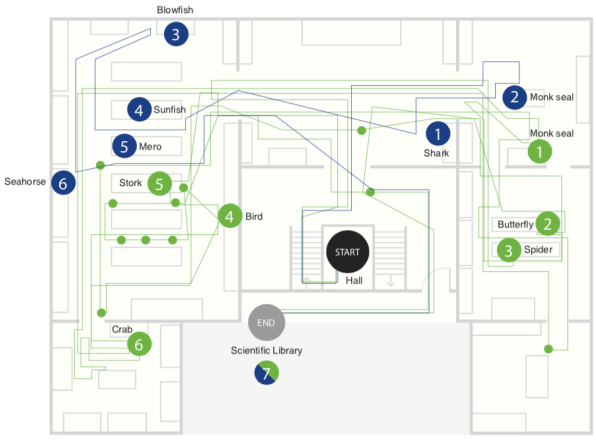


Figure 68. *Path from the 'Uncomfortable' visitors observed in the museum with the game-based strategy 'Haunted Encounters'. The different colours of the numbered dots and lines correspond to the different versions of the app. The numbered dots correspond to the species in game visitors should encounter in their version. The dots without a number correspond to the stops visitors made in the museum to see other exhibits.*

CONCLUSIONS FROM APPROACH #1

According to this study, at the beginning of the tour, we cannot label the teenagers as specific types of visitor and assign them to a specific strategy but we do can label the attitudes each strategy would generate in the teenagers. Results show four main attitudes of teens, displayed through both game-based and story-based strategies: (i) *Gamers*, (ii) *Explorers*, (iii) *Uncomfortable*, and (iv) *Followers*.

Gamers (*Skippers* and *Competitors)* toured the museum by following the app instead of engaging with the exhibits. *Gamers* stuck exclusively to the app while *Explorers* (*Achievers* and *Adventurous*) went beyond the app and took in more of the museum than what was strictly asked. As in *Mystery in the Museum* (Cabrera et al., 2005) and *Ghost Detector* (Nilsson, Hogsden, et al., 2016), the focus on the apps can push visitors to run through the museum either competing or captured by the usability of the interface (or lack of) and thus paying attention to the smartphone. *Uncomfortable* and *Followers* are the expression of the same category in the two strategies, due to the fact that the game-based approach forced them to compete and make choices, while the story-based approach did not, so they could proceed without having to take any decisions. However, *Followers* are similar to *Adventurous*, as both types appreciate the museum and tend to talk about the exhibits and relate them to their personal experiences. Different strategies also impact the dynamics between teenagers, as categories shift when the teenagers' goals change. *Gamers* in the game-based approach (*Competitors*) become *frenemies*, while in the story-based approach (*Skippers*), they become *lovebirds*. The plot in the story-based approach was not engaging for *Skippers*, as visitors had to stop and listen to it. For this reason, *Skippers* started to skip as *lovebirds*, without any disagreements, because they wanted to finish the story as quickly as possible. Moreover, the game-based approach encouraged competition between the teenagers in a pair; both wanted to take on the leading role and one would frequently blame the other for lost points or incorrect answers. Encouraging competition among teenage visitors could generate different attitudes (*Gamers*, *Uncomfortable*). However, a problem arises when visitors start running through the halls in search of the correct exhibit without looking around and taking in the museums' content. This happens with *Gamers* (*Competitors* and *Skippers*), as they are pushed by competition. The feeling of personal improvement, in the case of *Achievers*, could be seen and encouraged in a museum tour, as *Achievers* like to explore the museum carefully, learn about the exhibits, and progress in the task without competing against others. Another problem arises when teenagers are too concerned about others and too worried about not being good as far as understanding the competition: this happens with *Uncomfortable* visitors.

Through the visitors' paths, we verified that participants explored more the museum and checked out other species when touring the museum with the game-based *Haunted Encounters* than they did with the story-based *Turning Point*, as these approaches share the same exhibits but displaying different content in each. Different strategies can be implemented for different intentions depending on what museums want to highlight in an exhibition and the type of experience they want their visitors to have.

The above findings can be summarized through the crossing of two factors (Fig. 69): (i) the amount of exploration of the museum space where visitors relate the exhibits to their past experiences (findings from their recordings, interviews and paths taken), and (ii) the visitors' progress lived as competition such that they want to be the best and are worried about their progression within the mobile experience (findings from their recordings and interviews).

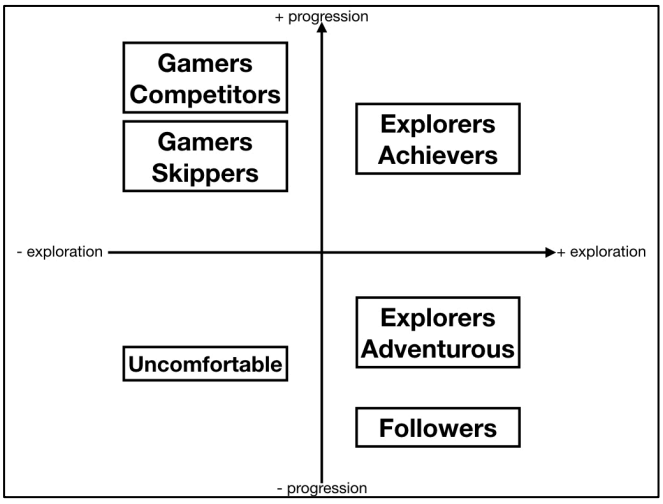


Figure 69. *Taxonomy of the proposed classification on teenage visitor experience split by exploration and progression.*

Plotting the visitors' types according to the two axis of exploration and progress degrees we have the six visitors typologies summarised below. Those visitors who are worried about their progress and who, at the same time, are willing to explore the museum are *Explorers-Achievers*. Those who are willing to explore the place and are less concerned about their in-game progression are *Explorers-Adventurous* and *Followers*. Moreover, *Followers'* behaviour could be classified as passive: they listen to the narratives in full and follow the story unfold. Those who are worried about their progress and who focus less on exploring the museum are *Gamers – Competitors* and *Skippers*; they are motivated by competition. Those who are concerned about neither exploring the museum nor their progress are *Uncomfortable*; they simply want to finish the experience and not be the last ones to do so, and thus they can be considered as passive.

Results from this study show that it is possible to understand which attitudes, in terms of exploration and progression, teenagers could adopt in a museum when using either story-based or game-based mobile strategies. Overall, game-based and story-based strategies would make teenage visitors to adopt either attitudes of active visitors (*Gamers*, *Explorers*) and passive visitors (*Uncomfortable* and *Followers*). Reflecting on these findings, two diverging approaches are possible: to design for changing visitor's attitude, and designing for the visitor's attitude.

How to design to change *Gamers* attitudes? *Gamers* respond strongly to competition elements, and thus a problem arises when visitors switch their focus from the museum experience to the mobile game and start running through the halls in search of the right exhibit, without looking at and enjoying the museum itself, which is not the goal of the museum. If from one side competition can motivate, on the other it risks to focus them too much on the game mechanics and neglecting the museum environment by preventing them to pay attention to the exhibition. Time strategies and scoring points are a critical element in the design of museum experiences, thus games in museum should be carefully designed. A possible solution to prevent visitors from rushing is to reverse the time approach: let those at a slower pace win the competition, or propose games that accommodate contemplative behaviours. Puzzles could invite *Gamers* to spend time thinking and discussing the exhibits. However, the scoring of the performance should be based on accuracy of the answer rather than fast answers, and also based on the depth of the answer.

How to design for *Explorers*? *Explorers* are somehow the easier type to design a pleasurable for, as they are fascinated by both the experiences and the museum in general. Suggestions stemming from these findings point to care being taken into harmonising the experience for the *Explorers* that display *frenemies* attitudes as a pair. Possibly assigning different tasks to each visitor to achieve a single goal: for example, one could go find an exhibit to provide partial answers to a quiz, while the other looks at some other information to bring together to complete the task.

How to turn passive visitors (*Uncomfortable* and *Followers*) into active visitors? Interactive elements that require decision-making could be introduced to challenge the *Followers* and gently push them to be more engaged with the exhibition, such as a multiple choices narrative that requires visitors to decide which way to go, for the plot to unfold. To choose imply action: appropriation as well as navigation of the museum. In this way, *Followers* take an active part in the experience by creating their own story while visiting the exhibition. *Uncomfortable* teenagers might not pay enough attention to tutorials and, thus, might not learn

how the mobile app works, as these visitors might be distracted by the desire to simply try out the app. Museum experience designers should pay attention to this type of visitors, as their discomfort might influence the museum experience. Care should be spent in making them feel adequate, and make sure they take in the needed info before starting the digital experience. Special kind of tutorial could be designed for this type, encouraging them to take on challenges, in small steps, one at the time, and reinforcing their self-esteem, downplaying competition elements.

From the research study, I learnt about the inherent difficulty of some tasks: do not know the museum premises and the excitement of handling a high-tech smartphone. If visitors do not know the museum premises, as a consequence, some exhibits might be hard to find. And, the excitement of handling a high-tech smartphone might arise nervous behaviours (as seen in the Uncomfortable type of visitor). Since these dimensions are dependent on the visitor's past experiences, they could happen either by whether the teenagers visit the museum on a school visit or with their family/friends.

5.3. APPROACH #2: STORY-BASED VS GAME-BASED

ANALYSIS

A total of 159 users tested both apps (67 tested the story-based *Turning Point*, and 92 users tested the game-based *Haunted Encounters*), they were interviewed and answered post-questionnaires. The interviews were transcribed and coded through thematic analysis using NVivo 12, and the results of the post questionnaires were inserted into SPSS to apply statistical tests and understand if there was any difference between both apps.

RESULTS

INTERVIEWS

The interviews of the 159 users were transcribed and analysed through thematic analysis. Each of the 4 topics covered during by the interview were analysed for each mobile experience: (i) general comments, (ii) the best features, (iii) the worst features, (iv) improvements to apply, (v) awareness – what they remembered about the experience. Below are the reported results split by mobile app.

STORY-BASED: TURNING POINT

This section describes the results of the interviews[18] to the 67 users, split by the 5 topics. Hereinafter I report the topics along with their themes, codes and references (times occurred):

- General comments (5 themes, 11 codes, 76 references)
- The best features (4 themes, 12 codes, 67 references)
- The worst features (4 themes, 7 codes, 38 references)
- Improvements (3 themes, 9 codes, 24 references)
- Awareness (10 themes, 33 codes, 57 references)

[18] Strangely the selfie was not mentioned at all in the interviews. Participants were concerned in looking good in the selfie, and since they did not know they will be prompt in taking one, some of them did not like their look (fact: the recordings and observations confirmed this). I believe that since participants were not using their own smartphones, they did not keep their selfies. Further studies could shed light on this issue.

Table 24 describes the general comments made by the participants right after the end of the experience *Turning Point*. This analysis encompasses 5 themes ('Exploration', 'Story', 'Learning', 'Interaction', 'Cool'), with a total of 11 codes and 76 references.

Table 24. *Map of the themes and codes identified under the topic 'General Comments' during the interview after participants had experienced Turning Point.*

Theme	Code (references)	Description
EXPLORATION	*Search for specific species (18)*	Search for specific species prompt by the mobile app which would enable them to discover fragments of a story.
	Explore the museum (5)	They explore the museum by walking around its rooms.
STORY	*The story of the building (18)*	They explored the museum by following a story given by different species. This story encouraged them to get to know more about the story behind the museum: the story of its building and the family who lived there.
	Preserve the monkseals (3)	They got to know the story behind the preservation of the monkseals, an endangered species, and the law to protect its species.
LEARNING	*Get to know more (15)*	Enrich their knowledge by getting to know through a story the different species exhibited in the museum as mammals and sea birds, as well as the museum building.
INTERACTION	*Interactive tour (3)*	They performed an interactive tour where they were able to identify different species.
	Testing of a mobile app (3)	They used a smartphone to test a mobile app that was developed.
	A game (2)	Teenagers related the experience as a game to search for specific species.
	Unravel a mystery (1)	Unravel the mystery of the whole story.
COOL	*Cool (5)*	Teenagers found the app as cool, being different from a regular one without technology.
	Interesting (3)	Teenagers found the experience as an interesting way to get to know animal species and plants through an app.

The theme 'Exploration' (2 codes, 23 references) describes the exploration made by the pairs throughout the museum, exploring the space in search of what was requested.

The theme 'Story' (2 codes, 21 references) is regarding how teenagers related the mobile experience with a story.

The theme 'Learning' (1 code, 15 references) is regarding how they got to know more with the mobile experience.

The theme 'Interaction' (4 codes, 9 references) describes the reflection on the mobile interaction.

The theme 'Cool' relates the mobile experience as cool, being different from a regular one without technology.

Table 25 describes the features participants liked the most. This analysis encompasses 4 themes (‘Exploration’, ‘Species’, ‘Story’, ‘Technology’), a total of 12 codes and 67 references.

Table 25. *Map of the themes and codes identified under the topic ‘The best features’ during the interview after participants had experienced Turning Point.*

Theme	Code (references)	Description
EXPLORATION	*Search for species (28)*	They liked explore the museum to search and get to know the species exhibited.
	See the museum (1)	They liked to see the museum as it is.
SPECIES	*Check species exhibited in their real shape (11)*	They liked to check and be near the species in their real shape.
	Plants (4)	They liked to check the garden and its aromatic and medicinal plants.
	Other species (1)	Other species exhibits, not part of the mobile experience, caught the user’s attention due to its dimension.
STORY	*Story (9)*	They liked the fact they took an active part in the mobile app by going to different species to unravel the story.
	Voices of the story (6)	They liked the audio-narration of the story. The voices showed emotion and were funny.
	Texts from the story (1)	They liked the texts appearing telling the story.
TECHNOLOGY	*Technology (3)*	They valued the interaction with the mobile phone and the museum: catch a marker and unlock a story.
	Graphics (1)	They liked the graphics of the mobile app.
	Innovation (1)	They liked that it was a different tour to take.
	Mobile app (1)	The mobile app was very organized, telling the user where they should go, and the species were near each other, not far away.

The theme ‘Exploration’ (2 codes, 29 references) describes exploration as a desired feature. Participants liked exploring the museum to search and get to know the species exhibited and the building.

The theme ‘Species’ (3 codes, 16 references) is regarding how participants liked to verify the exhibits along the mobile tour.

The theme ‘Story’ (3 codes, 16 references) inform us that participants liked having a story to follow.

The theme ‘Technology’ (4 codes, 6 references) inform us that participants related the technology of the mobile all as a good feature.

Table 26 describes the features that participants did not like during the mobile experience. This analysis encompasses of 4 themes ('Story extension', 'Difficult', 'Map', 'Not engaging'), with a total of 7 codes as 38 references.

Table 26. *Map of the themes and codes identified under the topic 'The worst features' during the interview after participants had experienced Turning Point.*

Theme	Code (references)	Description
STORY EXTENSION	*Story too long (23)*	The story was boring as the users should be in a specific location to listen to a lot of story in row.
	Too much to read (2)	The app had too much text to read.
	Too much dialogue (1)	The story had too much dialogue they should listen.
DIFFICULT	*Difficult to encounter the species in the garden (6)*	The garden was big with a lot of species which caused confusion in the teenagers, who described the searching in the garden as complex.
MAP	*Map (4)*	Difficult to understand the map in the garden, as well as the transition from the garden to the museum.
NOT ENGAGING	*Characters speak slow (1)*	The characters spoke very slow and users needed to hear them and also reading their texts.
	Story not engaging (1)	The story was not engaging enough to catch their attention, they would change the plot.

The theme 'Story extension' (3 codes, 26 references) describes the story as too long. Although participants mentioned they enjoyed the story under the previous topic 'the best features' (total of 16 references), they did also say that, however, it was too long under this topic 'the worst features' (total of 26 references).

The theme 'Difficult' (1 code, 6 references) describes issues encountered while in the tour.

The theme 'Map' (1 code, 4 references) inform us that the map in the garden was difficult to understand, as well as the transition from the garden to the museum.

The theme 'Not engaging' (2 codes, 2 references) relates the mobile tour as not appealing. The story was not engaging enough to catch their attention, they would change the plot.

Table 27 describes the improvements that the mobile tour could use it, pointed out by the participants. This analysis encompasses of 3 themes ('Story', 'Challenge', 'Information') with a total of 9 codes and 24 references.

Table 27. *Map of the themes and codes identified under the topic 'Improvements' during the interview after participants had experienced Turning Point.*

Theme	Code (references)	Description
STORY	*Shorten the story (9)*	Shorten the story in each point of interest where users need to be stopped to listening to it.
	Put voices faster (3)	Increase the speed in the voices of the characters.
	Put voices slower (1)	Decrease the speed in the voices of the characters.
	Remove the text (1)	Remove the text ad they were listing the audios.
CHALLENGE	*Add questions (4)*	Add questions to augment the competition among users.
	More species (1)	More species for the users to encounter.
	Ranking (1)	Add a ranking at the end with the points of the questions to enhance the competition among players.
INFORMATION	*Add videos about the animals (2)*	Add videos about the species in their natural habitat.
	More info (2)	Add more details about the species.

The theme 'Story' (4 codes, 14 references) inform us how the story should be improved.

The theme 'Challenge' (3 codes, 6 references) inform us on how the tour should be improved by competition.

The theme 'Information' (2 codes, 4 references) inform us that the tour is in need of displaying more info to the users.

Table 28 describes what participants remembered after the experience. This analysis encompasses 10 themes ('Shape', 'Characters', 'Story – species', 'Curiosity', 'Hard to find', 'Imprecise', 'Past experiences', 'Story voices', 'Hunting', 'Technology') with a total of 33 codes and 57 references.

Table 28. *Map of the themes and codes identified under the topic 'Awareness' during the interview after participants had experienced Turning Point.*

Theme	Code (references)	Description
SHAPE	*Turtle shape (3)*	Big species on the floor.
	Monkseal shape (2)	This is a very massive species in the museum.
	Seahorse shape (2)	Its dimension. Users thought it was bigger.
	Sensitive plant (2)	When touching this plant, it would close its leaves.
	Spider shape (2)	A lot of spiders at once.
	Bird shape (1)	The user had never seen this species.
	Shark shape (1)	Big species exhibited.
	Sugar cane (1)	Species.
CHARACTERS	*Character Marina (7)*	Marina inherited her mother's powers, did not marry Xavier, transformed into a monkseal, and after her death she became a ghost.
	Character Xavier (2)	Challenging moment between Xavier and the dolphin: the dolphin challenges Xavier to go to talk to other species exhibited in the museum. Also, the moment between Xavier and his father killing the monkseal.
	Character Ghost (1)	They remembered about the ghost in the museum.
	Character Isabel (1)	This character had an arrogant voice.
	Characters Xavier and Marina (1)	They were separated of each other because of a misunderstanding.
STORY - SPECIES	*Monkseal story (5)*	Marina transformed herself into a monkseal. The monkseal was killed by fisherman. The monkseal in the story was Marina.
	Dolphin story (4)	Funny character in the story.
	Spider story (1)	Funny part where the spider tells she's afraid of biting Isabel, as Isabel is more poisoner than she.
CURIOSITY	*Crab curiosity (1)*	Crabs change colour depending on their habitat.
	Monkseal curiosity (1)	Endangered species.
	Shark curiosity (1)	This shark has 360º vision.
	Turtle curiosity (1)	Turtle came from Mexico.
HARD TO FIND	Seahorse jar (2)	They remembered about is as it was in a jar, different from the others.
	Fennel hard to find (1)	It was hard to find.
	Seahorse hard to find (1)	It was very hard to find as it was in a jar.
IMPRECISE	*Plants in general (2)*	They had awareness of the plants in general, not any specific, but plants.
	Not the story but species in general (1)	Do not remember about the story but rather the animals they needed to find.
PAST EXPERIENCES	*Spider fear (2)*	They do not like spiders.
	Bird past experience (1)	User already knew how this bird will look like.
STORY VOICES	*Crab voice (1)*	The crab had a funny voice.
	Seahorse voice (1)	Seahorse had an interesting voice.
	Turtle voice (1)	The turtle talked very slow.
HUNTING	*Animals hunting (1)*	Fishermen hunted monkseals.
	Monkseal hunting (1)	The monkseals at the beginning were hunted in Câmara de Lobos area and then this was forbidden.
TECHNOLOGY	*Monkeal selfie (2)*	It was near this species that the experience finished and users were invited to take a selfie

The theme 'Shape' (8 codes, 14 references) describes the participants remembered specific species due to its dimension (big or small) and details.

The theme ‘Characters’ (5 codes, 12 references) describes the characters participants remembered after the mobile experience.

The theme ‘Story – Species’ (3 codes, 10 references) inform us that the species the participants remembered because of their role in the story and not because their scientific facts.

The theme ‘Curiosity’ (4 codes, 4 references) describes the species participants remembered their scientific facts.

The theme ‘Hard to find’ (3 codes, 4 references) describes the species that were difficult to encounter during the tour.

The theme ‘Imprecise’ (2 codes, 3 references) describes that participants did not remember any species in specific.

The theme ‘Past experience’ (2 codes, 3 references) describes which species participants related with their past experiences.

The theme ‘Story voices’ (3 codes, 3 references) inform us the species participants remembered because their voices.

The theme ‘Hunting’ (2 codes, 2 references) describes the participants remembered about the animal hunting displayed in the story.

The theme ‘Technology’ (1 code, 2 references) describes aspects of the technology relate to an exhibit.

Game-based: Haunted Encounters

This section describes the results of the interviews to the 92 users, split by 6 topics. During the interviews participants asked several questions about the exhibition and by which this was considered a topic as well. In sum, below I report the topics along with their themes, codes and references (times occurred):

- General comments: 5 themes, 14 codes, 131 references
- The best features: 6 themes, 9 codes, 117 references
- The worst features: 7 themes, 15 codes, 46 references
- Improvements: 5 themes, 14 codes, 50 references
- Awareness: 10 themes, 43 codes, 130 references
- Questions Asked: 1 theme, 1 code, 4 references

Table 29 described the general comments made by the participants right after the end of the experience. This analysis encompasses 5 themes ('Cool', 'Interaction', 'Learning', 'Exploration', 'Not engaging'), a total of 14 codes and 131 references.

Table 29. *Map of the themes and codes identified under the topic 'General Comments' during the interview after participants had experienced Haunted Encounters.*

Theme	Code (references)	Description
COOL	*A cool activity (16)*	It was a cool activity to tour the museum.
	An interesting activity (13)	Participants had never done something like this, a tour like this is more interesting to take.
	liked it (8)	Participants liked the activity.
	A good activity (7)	Participants think it was a good activity
	A funny activity (4)	It was funny.
	Easy to take (1)	It was very intuitive.
EXPLORATION	*Encounter of different locations (15)*	Walking throughout the museum to explore/search for several species and locations in the museum
INTERACTION	*Playing a game (19)*	Act of playing a game: treasure hunt, in search for animals, answer questions regarding each animal
	Interactive activity (12)	Relate the tour as an interactive activity with an app of Augmented Reality. Interactive game to walk around the museum and at the same time to search for animals.
	Technologies (8)	Participants had a smartphone to test an app.
	Uncover a mystery (1)	Uncover the mystery of the museum.
LEARNING	*Increase knowledge (24)*	Get to know new species and learn more about them.
NOT ENGAGING	*The theme was not of interest (2)*	Participants were not interested in the theme, because they needed to walk around the museum, and the museum theme did not catch their attention.
	Too fast (1)	It was too fast, they thought it would take more time to pursue the activity.

The theme 'Cool' (6 codes, 49 references) describes the attractiveness of the experience.

The theme 'Exploration' (1 code, 15 references) describes the tour as a way to walking throughout the museum to explore/search for several species and locations.

The theme 'Interaction' (4 codes, 40 references) describes the tour as an interactive activity.

The theme 'Learning' (1 code, 24 references) describes the tour has getting to know new species and learn more about them.

The theme 'Not engaging' (2 codes, 3 references) describes the exhibition not appealing enough to catch the participants' attention.

Table 30 describes the features the participants enjoyed during the mobile tour with *Haunted Encounters*. This analysis encompasses 6 themes ('Species', 'Exploration', 'Learning', 'Challenge', 'Technology', 'Team group'), a total of 9 codes and 177 references.

Table 30. *Map of the themes and codes identified under the topic 'The best features' during the interview after participants had experienced Haunted Encounters.*

Theme	Code (references)	Description
SPECIES	*Watch the 3D models (23)*	Participants enjoyed the interaction through Augmented Reality to check the 3D models of the species: they could rotate and check the model carefully.
	Watch the species in their real shape (15)	Participants liked seeing the animals exhibited in their real shapes, some of them they had never seen.
EXPLORATION	*Search (35)*	Participants liked the idea of walking freely and searching for the runes and the species in the museum through the clues given, also visiting places never visited in the museum, such as several rooms and the library.
LEARNING	*To learn (18)*	Participants liked learning and discovering several facts about museum's species, facts that if they were told in another way it would be difficult for them to learn. Also, the act of looking at the real exhibit in search of the right answer allowed users to learn more about specific facts.
CHALLENGE	*Uncover the mystery (11)*	Have the map and get to the library in search of the treasure hunt to unlock the mystery and discover ghosts.
	Competition (5)	The competition of answering the questions the app proposed.
TECHNOLOGY	*The integration of new technologies in the museum (8)*	Participants state the museum supported by technology is no longer 'boring'. They think the whole experience innovative as they are trying an app never seen in a museum.
	Have other's smartphone (1)	Participants liked the museum share with users the phones for them to take the tour, rather than the need of previously downloading an app.
TEAM GROUP	*Working in pairs (1)*	Participants liked being in pairs and support each other throughout the tour.

The theme 'Species' (2 codes, 38 references) describes the exhibits as engaging to perceive.

The theme 'Exploration' (1 code, 35 references) describes the searching of the museum building.

The theme 'Learning' (1 code, 18 references) describes the tour as a way of learning new content.

The theme 'Challenge' (2 codes, 16 references) describes the competition as treasure hunt as interesting.

The theme 'Technology' (2 codes, 9 references) refers to the technology participants had access for the tour.

The theme 'Team group' (1 code, 1 reference) describes the fact participants liked being in pairs.

Table 31 describes the features participants disliked during the tour. This analysis encompasses 7 themes ('Not engaging', 'Barrier', 'Difficult', 'Game focus', 'Library', 'Failure', 'Selfies') with a total of 15 codes and 46 references.

Table 31. *Map of the themes and codes identified under the topic 'The worst features' during the interview after participants had experienced Haunted Encounters.*

Theme	Code (references)	Description
NOT ENGAGING	*Too easy (5)*	The search of just 6 animals was too easy, as well as the questions.
	Not for my age (3)	Participants found the app childish: the 3D model of the exhibits, and the ghosts encountered at the end.
	3D not realistic (2)	The 3D could be more realistic and show more details inside of the species (their organs).
	Treasure chest not well hidden (1)	The treasure chest was too easy to find, not well hidden.
BARRIER	*Short experience (6)*	The experience had few animals and thus short.
	Bugs (1)	The button 'X' to leave the 3D and start de quiz was sometimes slow to move to the quiz screen.
	Fear of the ghosts (1)	Participants would take out the ghost part as they got scared.
DIFFICULT	*Difficult questions (3)*	Some questions were difficult to guess the right answer (seahorse).
	Treasure chest hard to find (3)	The treasure chest was hard to find in the library, being ***a*** difficult part as participants did not have a clue about where the treasure chest would be hidden inside the library.
	Some species were difficult to encounter (2)	Some species were difficult to encounter as they were small (as the seahorse) which required visitors to take differ paths to encounter it.
GAME FOCUS	*Focus on the game (7)*	Participants paid more attention to the species the game proposed than to the museum itself. The app just shows specific animals, specific places. It does not prompt the user to find/discover others. They were too focused playing the game, paying more attention to the 3D models than the exhibited species themselves. They just stuck with the species of the version they were using: or the marine species, or the land ones.
LIBRARY	*Boring to look for the treasure chest inside the library (6)*	It was 'boring' to look for the treasure chest inside the library because it was inside a library, participants did not like the place itself, neither the act of searching for a treasure chest.
FAILURE	*Lose points (3)*	Participants did not like losing points throughout the tour by wrongly answer to the questions, or asking for help in the app, or losing the points at the final because of the ghost encountered.
	Fail the answers to the questions (1)	Participants did not like losing points with wrong answers.
SELFIES	*Take selfies (2)*	Participants did not like to take a selfie at the beginning.

The theme 'Not engaging' (4 codes, 11 references), describes the mobile tour as not engaging.

The theme 'Barrier' (3 codes, 8 references) describes the barriers to the experience that participants did not like, compromising the whole experience.

The theme 'Difficult' (3 codes, 8 references) describes the difficulties encountered throughout the mobile tour.

The theme 'Game focus' (1 code, 7 references) describes the mobile tour just focusing on a game and not the museum.

The theme ‘Library’ (1 code, 6 references) describes the library as a place not appealing to go.

The theme ‘Failure’ (2 codes, 4 references) describes the moments participants failed something.

The theme ‘Selfies’ (1 code, 2 references) describes the fact that participants did not like to take a selfie at the beginning.

Table 32 describes the improvements that the mobile app could use with. This analysis encompasses 5 themes ('Challenge', 'Different tours', 'Information', 'Questions', 'Markers') with a total of 14 codes and 50 references.

Table 32. *Map of the themes and codes identified under the topic 'Improvements' during the interview after participants had experienced Haunted Encounters.*

Theme	Code (references)	Description
CHALLENGE	*More species (19)*	Increase the number of species to encounter for the experience to be longer. Also, merge with other species of plants.
	Increase the challenge (8)	Increase the overall difficulty of the experience for it to be more challenging.
	Adapt for different age groups (3)	The app should be adapted for different age groups: for teenagers should be more difficult/challenging. Also, teenagers like go to see the exhibits they are interested: if they like something specific they go to search for it.
	More rooms (3)	The experience should embrace more rooms and not being only concentrated in one room or floor.
	Markers should be hidden (2)	Markers should be more hidden in order to increase the challenge.
	More questions (1)	The experience should provide more quizzes.
	More steps to uncover the mystery (1)	The experience should embrace more steps for the discovering of the mystery.
	Remove shadows (1)	Remove the shadows as clues, just give sentences as clues.
DIFFERENT TOURS	*More characters providing different routes (3)*	Add more characters with different routes at the beginning for them to have more choice for them to check in the museum.
	More groups of species (2)	Since the museum has a lot of variety in natural history, the species should be categorized by their type: mammals, birds, plants.
INFORMATION	*More info about the species (3)*	Add more information about the species: habitats, and tips on how to preserve the species.
	Better vocabulary (1)	There was one word that was difficult to understand, 'cataloguing', which was in the seahorse question and created conflict between teenagers.
QUESTIONS	*Change questions (2)*	Do not ask questions too specific about the members of the species. They did not realize they should be looking at the exhibits.
MARKERS	*Markers position (1)*	The markers that are position in the downside shelves are seen as a negative note because teenagers need to crawl in order to scan the marker.

The theme 'Challenge' (8 codes, 38 references) describes the features to increase and make the tour more challenging.

The theme 'Different tours' (2 codes, 5 references) describes more options of tours.

The theme 'Information' (2 codes, 4 references) describes the app should give more information to the visitor.

The theme 'Questions' (1 code, 2 references) describes that the questions should be changed.

The theme 'Markers' (1 code, 1 reference) advises for the markers positioned in the lower shelves, as difficult to scan.

Table 33 describes what participants remembered about the experience. This analysis encompasses 10 themes ('Question', 'Shape', 'Curiosity', 'Past experiences', 'Imprecise', 'Wrong answer', 'Hard to find', 'Other species', 'Clue', 'Technical problems') with a total of 43 codes and 130 references.

Table 33. *Map of the themes and codes identified under the topic 'Awareness' during the interview after participants had experienced Haunted Encounters.*

Theme	Code (references)	Description
QUESTION	*Monkseal skeleton: Related question (10)*	How many bones are in one of its lower fins: 17.
	Monkseal embalmed species: Related question (9)	The monskeal's arm's bony structure is similar to the human's.
	Seahorse: Related question (8)	Its catalogue number is in its tail, not easy to check in the glass jar.
	Spider: The book gave the answer (7)	They were required to go to a book in the museum to solve the quiz.
	Butterfly: Related question (6)	The butterfly with more divisions in its lower wing.
	Dusky Grouper: Related question (4)	How may spikes the fish has in his upper fine: 11.
	Pufferfish: Related question (4)	How many fins are visible: 5.
	Crab: Related question (3)	How many species are in the shelf: 3.
	Stork: Related question (3)	Its colours: white and black.
	Bird: Related question (2)	Bird's feet similar to Duck's feet.
	Seahorse: The word in the question (2)	Participants did not know that 'catalogue number' meant.
	Shark: Related question (2)	How many fins: 7.
	Sunfish: Related question (2)	It is oval.
	Butterfly: Its name (1)	Monarc Butterfly
SHAPE	*Monkseal embalmed species: Its shape (5)*	Very big.
	Monkseal skeleton: Its shape (3)	Very big.
	Seahorse: The shape (3)	Very small, they thought it would be bigger.
	Spider: A lot of spiders at once (3)	They have never see a lot of spiders at once.
	Pufferfish: Its shape (2)	It's big and is upside down.
	Shark: Its shape (2)	Big.
	Stork: Its shape (2)	It is tall, and they have never seen one.
	Dusky Grouper: Its shape (1)	Very big.
	Sunfish: Its shape (1)	Big.
CURIOSITY	*Butterfly: Written curiosity (4)*	The butterfly's life cycle: 2-4 weeks.
	Dusky Grouper: Written curiosity (3)	Friendly and is photographed by divers.
	Monkseal embalmed species: Written curiosity (2)	The biggest mammal exhibited. There is only 40 monkseals in the Desertas Island.
	Spider: Written curiosity (2)	This species is less poison than the real Black Widow.
	Bird: Written curiosity (1)	Endangered species
	Crab: Written curiosity (1)	Find floating near the algae in the Atlantic Ocean.
	Shark: Written curiosity (1)	It has 360º vision.

(continues in the next page)

(continuation from previous page)		
PAST EXPERIENCES	*Spider: Fear (5)*	Participants have fear of spiders.
	Spider: Past experiences (2)	Or participants liked spiders, or they were bitten by one.
	Dusky Grouper: Past experiences (1)	The participant dives and take pictures to fishes.
	Monkseal embalmed species: Past experience (1)	The participant related it with the Porto Santo Cruise – that it is called "Lobo Marinho".
	Stork: Past experiences (1)	Participants recalled their childhood has there was this legend which says that storks brought the babies to earth.
	Sunfish: Past experiences (1)	Participants knew it was a big species.
IMPRECISE	*Species in general (7)*	Participants liked all the species, referring to the massive variety of them, not having one in mind at the moment of the interview.
WRONG ANSWER	*Monkseal embalmed species: Wrong answer (4)*	Participants failed the answer to the question.
	Seahorse: Wrong answer (1)	Participants failed the answer to the question.
HARD TO FIND	*Seahorse: Hard to find (3)*	Too small and in a glass jar: very different from the others.
OTHER SPECIES	*Other species (3)*	Species that were not covered by the game but teenagers encounter and appreciated: another shark, ray, other is general.
CLUE	*Sunfish: Its clue (1)*	The heaviest fish in the museum.
TECHNICAL PROBLEMS	*Monkseal embalmed species: Technical problems (1)*	At the beginning, the participant did not understand they should capture the marker and not the species itself, and the monkseal was their first species where they understood this.

The theme 'Question' (14 codes, 63 references) describes the answers of the questions related to each species that participants remembered as they were required to look at the exhibits in the shelves in order to correctly answer the questions proposed.

The theme 'Shape' (9 codes, 22 references) is related to the shape of the exhibits that caught the participants' attention by their dimension (or big or small).

The theme 'Curiosity' (7 codes, 14 references) is related to all the curiosities of the species that were mentioned in the mobile app and the participants remembered.

The theme 'Past experiences' describes that the participants related the exhibits with their past experiences, connecting deeper with those species.

The theme 'Imprecise' (1 code, 7 references) describes teenagers liked all the species, referring to the massive variety of them, not having one in mind at the moment of the interview.

The theme 'Wrong answer' (2 codes, 5 references) describes the participants remembered the species they failed correctly answer their questions.

The theme 'Hard to find' (1 code, 3 references) refers to those species' participants had trouble in finding.

The theme 'Other species' (1 code, 3 references) refers to those species that were not covered by the game but teenagers encountered and appreciated.

The theme 'Clue' (1 code, 1 reference) refers to the written clues participants remembered.

The theme 'Technical Problems' (1 code, 1 reference) describes the species they had technical problems.

Table 34 describes the questions participants made during the interview regarding the tour. This analysis encompasses 1 theme ('Curiosity') with a total of 1 code and 4 references.

Table 34. *Map of the themes and codes identified under the topic 'Questions Asked' during the interview after participants had experienced Haunted Encounters.*

Theme	Code (references)	Description
CURIOSITY	*Are they real? (4)*	Participants were curious and questioned about the reality of the species exhibited because seeing those animals was very new for them.

The theme 'Curiosity' (1 code, 4 references) describes the curiosity for the species exhibited.

POST-QUESTIONNAIRES

Statistical methods were applied to the results of the post-questionnaires to understand if there was any statistical difference between the two experiences: Museum Experience Scale (that assessed *engagement*, *knowledge*, *meaningful experience*, *emotional connection*), Multimedia Guide Scale (that assessed *general usability*, *learning and control* of the guide, *quality of interaction* of the guide), and Game Experience Questionnaire (that assessed *positive experience*, *negative experience*, *tiredness*, *returning to reality*).

I used the Kolmogorov-Smirnov test to check the normality of the data. All the variables listed above in italics were not normally distributed ($p<0.005$), hence I applied non-parametric tests – *Mann-Whitney Test*. Through this analysis it was found two significant results. In the results reported below, the Mean is greater than the Mdn (median). This is common for a distribution that is skewed to the right: bunched up toward the left and with a 'tail' stretching toward the right.

Emotional Connection levels are greater in the story-based approach (TP) (Mdn=3.80; Mean=90.57) than on game-based (HC) (Mdn=3.40; Mean=72.30). This difference is significant, U=2373.500, p=0.13, r=-0.20.

Tiredness levels are greater in the story-based approach (TP) (Mdn=0.00; Mean=92.62) than on the game-based (HC) (Mdn=0.00; Mean=70.81). This difference is significant, U=2236.500, p=0.000, r=-0.31.

In other words, teenagers felt more emotional connect but also more tired with *Turning Point* (story-based) than with *Haunted Encounters* (game-based).

Conclusions from Approach #2

Stories and games can promote positive experiences among teenagers during a mobile museum tour. Both experiences were described as 'cool' because of the interaction with technology, which helped teenagers learn about scientific facts while exploring the museum. However, teenagers do not enjoy an experience in which species are difficult to encounter, an experience with few animals to search for (as in *Haunted Encounters*), or an experience with a story that takes too long to unfold (as in *Turning Point*).

Teenagers are moved by competition. In both strategies, they heightened the challenge to promote competition among themselves. Additionally, they added more information about the species into the mobile app. In both strategies, participants remembered the shape of some species, scientific facts, the species that were hard to find, and their past experiences related to specific exhibits.

However, there were also differences between the two approaches. On the one hand, those who experienced *Haunted Encounters* indicated that the tour was too fast and that only a few species were available to search. On the other hand, those who experienced *Turning Point* indicated that there was a story guiding them throughout the tour. This finding suggests that participants were too engaged with the game and wished that more species were included so that they could continue the experience; additionally, the story played a significant role in guiding their museum tour.

Those who experienced *Haunted Encounters* ascribed more relevance to the opportunity to learn from the challenges encountered as team group, while those who experienced *Turning Point* simply referred to the characters in the story and not to any learning opportunities or challenges related to the exhibits. This finding suggests that story-based strategies can help teenage visitors engage with historical facts and understand the consequences and messages that the museum would like to convey, while game-based strategies, through quizzes and game mechanics, can help teenage visitors develop an awareness of scientific facts about the exhibits.

While in *Haunted Encounters*, teenagers indicated that they were focused on the game and wrongly answered the questions as negative points of the experience, for *Turning Point*, they reported that the story was too long and that the map was difficult to understand in the garden. On the one hand, those who experienced the story-based approach indicated that the story should be shorter. On the other hand, those who experienced the game-based approach indicated that the museum should offer more tours from which to choose from, that there should be more general questions about the exhibits, and that the markers should be better positioned with more care. These findings suggest that *Haunted Encounters* was too fast, while *Turning Point* was too long. The game-based approach should include more species (it had only six) and the story-based approach should be shorter so that teenagers are not stuck in the long dialogues and text. Participants believed that shortening the story would make it more appealing, while those who engaged with the game said they would increase the element of competition. In addition, teenagers felt more emotionally connected to *Turning Point* due to its plot and characters; they also felt more fatigued by the story than by the game. The first part of *Turning Point*, which took place in the garden, was more time-consuming, while in *Haunted Encounters*, the teens were actively searching for the exhibits only indoors.

Those who experienced *Turning Point* remembered the characters, the species that appeared in the story, the characters' voices, and the message of the story. Those who experienced *Haunted Encounters* remembered the wrong answers they had provided and other species that were not part of the game. This finding suggests that story-based approaches promote the museum's message through characters and plots, while game-based approaches promote the learning of scientific facts about species and promote exploration of the museum to discover other species that are not part of the gamified experience.

As an additional note, and as a limitation of the research study, in the game-based strategy *Haunted Encounters*, we had not measured the reaction of the participants when they received the book, in their email, containing pictures and scientific facts of the animals they engaged with during the tour. Moreover, having some pictures missing in the book could be a clever way to make "collectionists" return.

Chapter #6
GUIDELINES FOR DESIGN

This chapter reports on guidelines, based on what we learned after the validation of the *Memories of Carvalhal's Palace* (MoCP) dual experience with teenagers. The following guidelines can be used by experience designers and curators in the design of mobile museum tours in natural history museums.

Knowing the number of teenagers who visit a particular museum will not, in itself, reveal ways to increase the number of teenage visitors to that museum. Furthermore, a teenager's demographic information will not tell us anything about what that teenager wants to experience in a museum during a visit with his or her family or on a school trip. According to Falk (2009), it is crucial to think about target visitors in terms of their needs and the kind of experience they want, rather than in terms of more traditional audience types (children, teenagers, school field trips, tourism trips) and demographics (age, sex, location). These thoughts dictate the kinds of experiences they are seeking from museum tours.

Hereinafter, I provide 20 guidelines that should be kept in mind when designing and implementing story-based or game-based approaches to enhance the museum experience for teenagers (15-19 years old). I integrate the requirements used in the design of the *Memories of Carvalhal's Palace* dual experience (Chapter #4 – '*Requirements applied*') with a reflection in the form of guidelines for the design of mobile museum experiences targeted at teens. These guidelines are split into nine topics. Each topic lists the requirements used in the design and the derived guideline, accordingly. I first list the topics from the requirements shared in both approaches: (i) *Making memories*; (ii) *Usability & attractiveness*; (iii) *Exploration*; (iv) *Scientific info*; (v) *Digital interaction*; (vi) *Storytelling*; and (vii) *Gameplay*. Then I list the specific requirements used differently in each approach: (viii) *Story-based*; and (ix) *Game-based*. At the end of each topic, I create a contextualization regarding the findings and the selected topic; in this contextualization, I provide examples and suggestions for designers of museum experiences.

6.1. MAKING MEMORIES

Requirements	Guidelines
[RQ_01] Share the experience on *social media* channels **[RQ_02]** Make memories by taking *photos and selfies* with and without AR effects	**[G01]** If sharing the experience through social media is important to a museum, the museum should provide a downloadable app that teenagers can use on their own smartphones. Most of the teenagers enjoyed taking pictures with AR effects; however, they did not share these pictures on social media because they were not using their own mobiles. (from Approach #2, *Interviews*)

If the technologically mediated interactive experience promotes a fun and engaging tour, teenagers will share their memories of this tour through pictures and selfies on their social media networks. Our findings suggest that the 'new generation' considers taking pictures to be a novel approach (Napoli & Ewing, 2000). Teenagers, being socially-oriented, enjoy sharing memories of their experiences through their online communities. This fact relates to the *Experience-Seeking* visitors from Falk's (2009) taxonomy of visitor experience. Teenagers are eager to share, with others, their memories on social media channels, as well as to view photos taken by others. Furthermore, the act of sharing pictures serves not only to create memories of the experience but also as an advertisement for the experience and the museum itself, as it spreads the word among the teenage visitors' friends about the teenager's experiences in the museum. Hence, museum curators should focus on a specific marketing campaign to advertise the fun these teenage visitors will sure to have in order to gather their attention on taking the tour.

If teenage visitors are allowed to use only the museum's device and not their own device, the museum's device could have a feed where all visitors could share their picture and experience. This would allow teenagers to check on what others have done and also to share their pictures without having to use their own private social networks.

6.2. USABILITY & ATTRACTIVENESS

Requirements	Guidelines
[RQ_04] Simple *usage* of the mobile guide **[RQ_05]** The user interface and overall designs should be *appealing*	**[G02]** Mobile strategies should be easy to use, appealing, and understandable: Museums staff should make sure teenagers learn how to use the mobile app, not just through a digital tutorial, which teens sometimes skip. (from Approach #1, *Uncomfortable*)

Museums should make sure visitors do not avoid the tutorial of the mobile strategy, as this is critical if well done. If the mobile app is explained through use of a digital tutorial encompassing images of the interaction or screenshots of the app, the teenage visitor might not pay adequate attention to the tutorial and, thus, might not learn how the mobile app works, as the visitor might be distracted by the desire to simply try out the app. I suggest that the museum's staff makes sure that teens follow the tutorial or makes sure to show them video of the necessary interaction with the mobile app or present information about how the mobile app works by utilising the app to unlock digital content in situ.

Moreover, museum experience designers should conduct regular usability tests with the target users so that they understand what can be added or improved to foster a better and more exciting experience. If there are problems with the usability of the digital experience, teenagers will quickly lose interest in the scientific facts mentioned during the experience and will, instead, switch their focus to the lack of usability of the guide. Findings from this doctoral thesis also suggest that museum experience designers should focus on: (i) ensuring that all paths leading to the completion of digital tours are not obstructed and that they facilitate the passage of visitors (such as making sure that visitors are able to open closed doors, if necessary); (ii) measuring the amount of time that text appears on-screen, as if too much text is displayed in too short a period of time to read it, users end up frustrated; (iii) considering the inclusion of web links in the experience in terms of design and usability levels, as otherwise the user may not be aware of them and may not click on the additional material; and (iv) maintaining high-quality media (e.g., images and sound), as poor-quality media can compromise the experience.

6.3. EXPLORATION

Requirements	Guidelines
[RQ_06] See different exhibits when taking *different digital tours* **[RQ_08]** Prompt the discovery of *unknown rooms and places* inside the museum	**[G03]** Mobile strategies should allow the users to encounter different exhibits in the museum and to explore several facts about them. (from Approach #1, *Interviews*) **[G04]** The teenagers are interested in discovering unknown places inside the museum. Mobile strategies should allow for the encounter, inside the museum's premises, of different locations that are not known by the teenage visitors. (from Approach #2, *Interviews*) **[G05]** Mobile strategies that are intended to increase the exploration of the museum's premises should make use of non-linear strategies – which would prompt teenagers to check other exhibits not part of the experience – rather than linear strategies – which would prompt them to meet just the exhibits proposed by the mobile. (from Approach #2, *Visitors' Paths*)

Exhibits play an important role in virtual interaction throughout the mobile museum experience. The gamified experience should display information not only about the exhibits but also about the museum itself, such as an introduction to the building and how the exhibits are displayed. Teenagers are interested in taking more than one tour of the same museum and in being allowed to choose and interact with various exhibits on separate visits. In addition, teenagers are eager to choose from a list of categories of exhibits and to locate the exhibits themselves in the museum via a map. Moreover, teenagers would be more likely to explore the

museum to check out exhibits that are not part of the experience if a non-linear game-based strategy is used than if a linear story-based strategy is used.

Suggestions stemming from these finds point to harmonise the experience for visitors exploring the museum in pairs: possibly giving points for collaborative activities and assigning different tasks to each visitor to achieve a single goal. For example, one could go find an exhibit to provide partial answers to a quiz, while the other is looking at some other information to bring together to complete the task.

Concerning managing the visitors' attention between the device and museum space, mobile approaches should make good use between the device and the physical place to allow the user to look at exhibits in the shelves, not only to the ones displayed in the screen of the digital approach. With the game-based strategy HE, participants explored more the museum and had more attention to the exhibits on the shelves as they needed to answer questions about these.

6.4. SCIENTIFIC INFO

Requirements	Guidelines
[RQ_09] Receive *information about the exhibits* through descriptive texts and plain images, access to their natural sounds and videos in their natural habitats	**[G06]** Mobile strategies should allow the user to input information in order to progress in the experience (such as questions implemented in *Haunted Encounters*) and provide the user with information not only about the exhibits but also about the overall story plot. (from Approach #1, *Followers*; and Approach #2, *Interviews*) **[G07]** Gamified strategies should promote a connection between the exhibits displayed and the visitors' past experiences, which would promote curiosity in the teenage visitors to explore the museum. (from Approach #1, *Explorers*, *Followers*, and *Uncomfortable;* Approach #2, *Interviews*)

The findings of this doctoral thesis indicate that videos about the featured species in their natural habitats were seen as positive elements of the tour. Technology can create personal connections between the teenage user and the information content, inspiring teenagers to take a closer look. The inclusion of connections between teenagers' past experiences/memories and the exhibition is positive and engaging, as the teenagers are seeking to obtain a general overview of the museum through informal themes rather than specific knowledge through more formal themes.

I suggest that museum curators partner with schools to learn about which content is being taught to teenagers that could be related to the museum's current exhibition. Museums should not let exhibits control the narrative; nor should they throw away the exhibition in favour of experiences. However, they should include exhibits that can support a big idea or question.

Finally, I also suggest that museum experience designers and curators engage in co-design sessions with teenagers to develop an understanding of which tours they would like to take. Teenagers are creative and have lots of ideas about how they would prefer to engage with museums; given the opportunity, they are excited to share these ideas. The findings from this doctoral thesis verified that teenagers were fully engaged in the creation of a mobile experience for a museum context in a co-design session and that they wanted to try these experiences in situ. In terms of engagement, the ability to create their own digital prototype can be more satisfying than having others do it. However, the performance of such co-design exercises does not imply that teenagers will successfully deliver and perceive all intended interactive experiences.

6.5. DIGITAL INTERACTION

Requirements	Guidelines
[RQ_12] Use of *location-aware technologies* for unlocking information	**[G08]** Mobile strategies should use location-aware technologies to catch the interest of teenagers in taking the tour. (from Approach #2, *Interviews;* Study #7, *Takeaways*)

Teenagers are attuned to experiencing cutting-edge technologies that unlock digital content related to the exhibits displayed in the museum. Teenagers wish to experience interaction through something novel. Even if teenagers are unfamiliar with the technology, they are excited to try it out because it is something novel. Such technologies include image recognition and proximity to unlock digital content, as well as AR 3D technologies to display models of exhibits and allow visitors to see their details, as the exhibits themselves are locked and untouchable behind a pane of glass. This doctoral research highlights that mobile strategies powered by location-aware technologies and digital interaction would mostly be described by teenagers as a cool and interesting activity. This 'novelty effect' is not an issue if there is no long-term interaction in museums.

Moreover, museum professionals find it difficult to put themselves in the teenagers' shoes, as they were educated in a very different era, with different sets of technologies. They prefer to think of an experience as a whole, without focusing much attention on the type of technology that can be used. I suggest that museum curators consult with active researchers and work with people (e.g., interaction designers, technologists, and storytellers) who have training in how to translate the topics they would like to convey in experiences.

6.6. STORYTELLING

Requirements	Guidelines
[RQ_13] Utilize *story-based* narratives to guide the experience **[RQ_14]** Base the story on an *adventurous journey*: teenagers tend to take on a leading role for themselves **[RQ_15]** Link an *emotional journey* within the museum: the exhibits that are part of this plot must be helped in some way by the users to generate an emotional impact	**[G09]** Story-based approaches can help teenage visitors engage with historical facts and understand their consequences and the messages that the museum would like to convey. (from Approach #2, *Interviews*)

Stories facilitate awareness of historical facts and an understanding of their consequences, as well as of the messages that the museum would like to convey. Stories play a significant role in displaying the journey upon which visitors will need to embark in search of something that will achieve an important goal. Teens have demonstrated an interest in being guided throughout the museum while immersed in a narrative plot: the teens' everyday engagement in relation to games is mediated through the adventure genre. The adventure trend highlights teenagers' interest in being the protagonists of exciting *adventures* and can be harnessed by museums to craft experiences that excite teens as well as communicate knowledge. Achieving an emotional reaction from teen visitors and taking them on a thrilling, emotional journey can lead to their engagement with the museum experience. Moreover, teenagers are creative and willing to share their stories when given the opportunity. To foster awareness of the exhibits, I suggest that museum curators create scientific curiosities in the form of tweet-sized messages that will catch teenage visitors' attention and not overwhelm them with too much information. The point is to create awareness of the overall museum message and its exhibits.

6.7. GAMEPLAY

Requirements	Guidelines
	[G10] The integration of challenges (searching for something, quizzes) promotes competition. (from Approach #1, *Gamers, Explorer-Achiever*, and *Uncomfortable*)
[RQ_16] Utilize *clues* in text and/or image format that can be combined with puzzles to challenge the teenage visitor	**[G11]** If competition is not the goal, museums should promote a story led mobile tour – a tour led by an adventurous plot and its exhibits, not led only by the game competition. (from Approach #1, *Gamers*)
[RQ_17] Search for and discover exhibits through *treasure hunts* and be provided with information about the same	**[G12]** If competition is not the goal, designers should avoid using words such as 'game' and 'points' in the digital strategy, or they should avoid referring to it as a 'game' so as not to encourage competition among teenagers. (from Approach #1, *Gamers* and *Uncomfortable*)
[RQ_19] Accomplish of in-game *achievements* through receiving points, unlocking information and increasing the level of the game	**[G13]** Precautions should be taken to avoid competitive visitors who cheat and disrupt the tours of their peers. (from Approach #1, *Gamers-Competitors*)
[RQ_20] Utilize *collection* of pieces (of exhibits or stories) to complete a puzzle and form a bigger picture	**[G14]** Exhibits that are hard to find could better engage certain types of visitors' attention. (from Approach #2, *Interviews*)

Technology would make a mundane visit more attractive. Teenagers would opt to use technological solutions to tour the museum in the form of a game. The game mechanics should include a collection of information, quizzes to test teenagers' knowledge, and clues that lead players through a treasure hunt. Collecting is a welcomed strategy of engaging teens, as after collecting pieces, they will have a bigger picture at the end. Challenges via quizzes and the ability to earn points promote competition and curiosity among teenage visitors in terms of who is best at completing the task. The deployment of clues for finding specific exhibits could enhance teenagers' museum experience as well as foster a possible increase in knowledge by allowing teenagers to solve these challenges. I suggest that museum experience designers mark the exhibits that are part of the gamified experience, as a visitor will not view all of the hundreds of exhibits in a museum to find the right one. Also, clues must be carefully aligned with the logic and purpose of the museum visit, as otherwise teens could be pushed through the exhibits too quickly, which would cause them to focus on finishing the visit rather than on enjoying it. However, the experience should be carefully considered so that it does not end up resembling a game.

Another problem arises when visitors switch their focus from the museum experience to the mobile game and start running through the halls in search of the right exhibit, without looking at and enjoying the museum itself. I suggest having museum's staff along the whole tour paying attention to the most competitive visitors, as these will be likely to disrupt the tours of their peers in order to be the best and completing the tour first. Players could become fascinated by the screen and fail to observe the physical exhibit in the museum, which might not be the museum's goal. Competition in a museum is appropriate when visitors explore the museum carefully, learn about the exhibits, and progress through the experience without competing against others. I suggest that, within the experience, museum experience designers create challenges that prompt teenagers to physically search for the right solution by checking out the real species exhibited, or by searching through a selected room or in books that the museum provides. This suggestion would require the visitors to take their attention away from the screen and to focus instead on the real-world environment surrounding them. Museum experience designers and curators should pay attention to the visitors who might appear to be uncomfortable with the tour, as their discomfort might influence the museum experience. Care should be spent in making sure they take in the needed info before starting the digital experience. Special kind of tutorial could be designed for these visitors, encouraging them to take on challenges, in small steps, one at the time, and reinforcing their self-esteem, moderating competition elements. Designing small team experiences in museums where participants are in

the midst of others that could potentially hinder their experience, is a challenging task. Possible solutions include propose games that accommodate contemplative behaviours: possibly assigning different tasks to each visitor to achieve a single goal. Puzzles could invite visitors to spend time thinking and discussing the exhibits. Ranking seems important as competition and performance are key factors for visitors displaying *Gamers* and *Achievers* attitudes. However, the scoring of the performance should be based on the accuracy of the answer rather than fast answers, e.g. micro-games and puzzles should score based on the depth of the answer. Answering by drawing (reproducing something in the museum) instead of taking photos, for example, could bring together details and observations in a timely fashion.

Mechanics play an important role in fostering awareness of selected exhibits: If the exhibits are hard to find or are associated with more challenging questions, teenagers will remember them better, and this is translated into a positive experience as these species would increase the engagement of the participants in the exploration of the space. I suggest that museums consider including small exhibits in the digital experience, and ensure that these exhibits are scattered around the museum. Small exhibits will always be more difficult to find and, thus, will require more attention from teenage visitors.

6.8. STORY-BASED

Requirements	Guidelines
[RQ_07] Guide the visitor through the museum by using a *map* to check out points of interest and locations **[RQ_10]** Display *curiosities and information about the museum* through general videos and descriptive information	**[G15]** The mobile strategy should provide feedback about the location of such exhibits through a map of the place. Most importantly, the map should be easy to understand. (from Approach #2, *Interviews*) **[G16]** The story fragments in the story-based approaches should be short and should not be time-consuming; otherwise, visitors will shift their focus from the story plot to the mechanics and, as a consequence, will lose interest in the content. (from Approach #1, *Skippers*; Approach #2, *Interviews*)

Teenagers are eager to acquire information about the location of the selected exhibits through a map. I suggest that, at the beginning of the experience, the museum's staff provide visitors with a map of the premises so that teens will understand the museum building and its rooms and be better prepared when checking the digital map highlighting the exhibits to encounter.

The findings of this doctoral thesis show that teenagers do not appreciate long dialogues and much text to read. Short and frequent fragments made the visit more dynamic, held interest of the teenage visitors better (avoiding skipping) and invited a wider exploration of the exhibition space, by moving more often to find exhibits that would release further story and scientific facts. Having a sharply edited story in the story-based strategy would make of paramount importance. Also, from a storytelling perspective, leaving parts of the story to be filled by the player can be exciting, although this aspect was not tested within the MoCP.

In addition, teenagers felt more emotionally connected to the story-based approach *Turning Point* due to its plot. The excitement in the voices of the characters promoted awareness of the plot. I suggest that museum experience designers and curators invest in a good

script and good voice actors, both of which can boost visitors' investment in the plot and lead them to gain awareness of the story and the overall message.

Suggestions stemming from these finds also point to harmonise the experience of the visitors who can be classified as passive – the ones just consuming the content and performing the actions required by the story-based experience. Interactive elements that require decision-making could be introduced to challenge and gently push them to be more engaged with the exhibition. For example, provide visitors with a multiple-choice narrative would require them to decide which exhibit to visit next, therefore determining where to go and what to encounter next, for the plot to unfold. In this way, visitors became active in creating their own story while visiting the exhibition. Additionally, these story plots should be carefully designed so the progress of the plot still relates to the museum exhibits.

6.9. GAME-BASED

Requirements	Guidelines
[RQ_11] Utilize *digital technologies* to augment the exhibits' physical information, such as *3D models*, Augmented Reality **[RQ_18]** Challenge teenagers' knowledge about the exhibits through *quizzes*	**[G17]** 3D models of the exhibits allow for detailed exploration through manipulation of the 3D model on the screen; this promotes engagement among teenagers. (from Approach #2, *Interviews*) **[G18]** Species exhibits that display challenging questions and locations would catch visitors' attention. (from Approach #2, *Interviews*) **[G19]** Game-based strategies should have a considerable number of species to encounter. (from Approach #2, *Interviews*) **[G20]** Game-based approaches including quizzes and game mechanics can help teenage visitors learn scientific facts about the exhibits. (from Approach #2, *Interviews*)

Some of the exhibits displayed in a natural history museum are locked and untouchable behind a pane of glass; hence, teenagers are interested in interacting with these exhibits through AR 3D models and being able to check out their physical details. I suggest that 3D models of the exhibits be developed by professional designers: this will be highly appreciated by teens. The 3D artists could even add the imperfections that can be seen in the real exhibit displayed. The replication of these imperfections will show the visitor that the 3D model is an exact replica of what is displayed on the museum shelf.

Challenging quizzes and metaphors will attract the attention of teenage visitors to the scientific facts about the exhibits. I suggest that museums use quizzes and metaphors that require a certain amount of wisdom to resolve, as exhibits that are harder to find will be better remembered than those that are easier to find.

The findings of this doctoral thesis reveal that users of the game-based strategy, *Haunted Encounters*, would increase the element of competition. Thus, games in museum should be carefully designed, time strategies or scoring points being a critical element. A possible strategy to make visitors progress in the experience without rushing could be letting those at the slower pace win the competition: the scoring of the performance should be based on accuracy of the answer rather than fast answers. Answering by reproducing something in the museum rather than answer a quiz could bring together details and observations in a timely approach. I also suggest that gamified museum experiences should allow for exploration of all of the species in the museum, and not just selected ones. The game-based strategy, *Haunted Encounters*, contained only six exhibits; hence, the experience was short in duration. The inclusion of such a small number of exhibits to encounter was seen as a negative aspect, as the teenagers preferred to encounter more exhibits and take part in a longer experience.

In summary, gamification and storytelling can go hand in hand. **Stories** facilitate awareness of historical facts and an understanding of their consequences, as well as of the messages that the museum would like to convey. To tour the museum, teenagers would opt to use technological solutions in the form of a **game**. Mechanics play an important role in fostering awareness of selected exhibits: if exhibits are hard to find or are associated with more challenging questions, teenagers will remember them better. Also, **challenges** promote competition and curiosity among teenage visitors in terms of who is best at completing the task. There are no right or wrong experiences: there are different strategies – whether story-based or game-based – that can be useful in different ways, depending on what curators and museums want to highlight and embrace in their exhibitions.

Moreover, the gamified experience should display information not only about the **exhibits** displayed but also about the museum itself. It should also allow teenagers to take more than one tour so that they can encounter different exhibits. The inclusion of connections between teenagers' past experiences/memories and **scientific information** about the exhibits is appealing, as teenage visitors seek to obtain a general overview of the museum through informal themes rather than specific knowledge through more formal themes. Teenagers enjoy sharing **memories** of their experiences through social networks. Also, museums should

concentrate on creating a marketing campaign that advertises the fun as well as the knowledge. Even if teenagers are unfamiliar with the proposed **digital interaction** and its technology, they would be excited to try it out because it is something novel. Last but not least, museum experience designers should conduct **usability tests** with target users so that they understand what can be added or improved to foster a better and more exciting experience.

Together, these guidelines form a roadmap to guide the development and maturation of a mobile museum experience solution that is targeted at teenagers (15-19 years old). In fact, I envisage that these findings can inform the design, research, and evaluation of interactive technologies in natural history museum contexts. I also foresee their application to other localities around the globe.

Chapter #7
CONCLUSIONS & FUTURE WORK

In this chapter, I propose conclusions by answering the initial research questions. I already presented individual conclusions for each individual research study in Chapter #3 – '*Methodology'*, and in Chapter #5 – '*Validation: Evaluation of the user experience*'. In this section, I go back to the research questions presented in Chapter #1 – '*Introduction'* and answer them based on all the results gathered and state which study or situation answered them. Finally, the last part of this chapter presents the main limitations of this research and elaborates on the future research lines on this topic.

7.1. ANSWERING THE RESEARCH QUESTIONS

WHAT TYPES OF EXPERIENCES WOULD TEENAGERS LIKE TO HAVE IN A MUSEUM?

To answer this research question, I report on the initial studies: the focus groups showing teenagers' perspectives on museums (study #1), the development of gaming museum experiences with teenagers (study #2), the study of patterns emerging from the design of museum experiences with and for teenagers (study #3), the results in terms of game mechanics and narrative plots from the work of teenagers (study #4), and the studies with curatorship students (study #6) and CHPs (study #7),

Teenagers would like to have access to appealing and unusual events in museums, contribute their ideas to an interactive experience that includes access to different technologies for interacting with exhibits in several different ways, and promote learning through playful approaches. If the experience is one-of-a-kind, teenagers are keen to make memories about it by discussing it on social media platforms.

Teenagers seek **unusual events** in museums that will catch their attention and lead them to take on a tour (study #1). They also seek a general overview of the exhibition rather than specific information through new information delivery styles (study #7). The discovery of new places in the museum building is seen as positive and engaging (study #7). Teenagers wish to have the chance to create their own prototype to be implemented in a museum, as they can make use of their **everyday engagement** to deliver an enjoyable experience to people their own age (study #2).

Teenagers appreciate the **promotion of learning** inside museums, as these institutions are powerhouses of knowledge. Any interactive experience should be aligned with the learning goals of the museum (study #1). It should display information not only about the exhibits but also about the museum itself, such as an introduction to the building and how the exhibits are displayed (study #3). Moreover, the connection between the exhibits and the visitors' previous experiences and memories is positive and exciting (studies #1, #7), inspiring teenagers to take a closer look.

Mobile interaction plays an essential role in attracting teenagers' attention through cutting-edge technologies (studies #1, #3, #6). The integration of videos featuring species in their natural habitats is a positive and encouraged component of any interactive museum experience (study #7). Also, to take on a more active role in the tour, users would like to interact

with the exhibits through virtual and augmented reality formats (studies #1, #3, #4) and acquire information about the location of such exhibits through a map (studies #3, #6). The technologies pointed out by the participants are often allied with playful **museum approaches**. The integration of games and challenges in an interactive museum tour (studies #1, #2, #3, #4, #6) and stories (studies #2, #4) were widely referenced by teenagers. The mentioned game mechanics included clues leading players through a treasure-hunt (studies #2, #4), the collection of information that formed a big picture at the end, and quizzes to put the teenagers' knowledge to the test. Challenges such as quizzes, the ability to earn points, and the existence of timeout strategies promote competition and curiosity among teenagers (studies #3, #4). On top of this, and certainly just as important, stories play a significant role in displaying the journey upon which visitors will need to embark in search of something that will achieve a significant goal (studies #2, #4).

If the experience is unique, teenagers are enthusiastic about **making memories** about this experience by taking photographs and sharing the experience on social media channels (studies #3, #6).

WHY DO TEENAGERS CHOOSE TECHNOLOGICALLY MEDIATED INTERACTIVE EXPERIENCES IN A MUSEUM?

To answer this research question, I report on the initial focus groups showing the perspective of teenagers on museums (study #1) and the study on design patterns from the designs of teenagers (study #3).

Teen participants like technologically mediated interactive experiences in a museum. These interactive experiences include cutting-edge technologies that provide information about the museum's exhibits, challenge the teenage visitors inside these institutions, and create memories about such technological experiences.

Participants from this study see museum tours as **mundane** and unengaging activities (study #1) that do not make use of technologies to make these tours more interesting (study #1). Teenagers find the integration of **cutting-edge technologies** in a museum as more appealing, as museums themselves do not attract members of this age group. Teenagers are attuned to experience cutting-edge technologies that unlock digital content related to the exhibits displayed in the museum (study #3). They are also keen to view this **content** in AR, VR, and video formats (studies #1, #3). Even if teenagers are unfamiliar with the technology, they are excited to try it out because it is something novel (study #1).

Teenagers would also opt to use technological solutions to tour the museum in the form of a **games and interactive stories**, as games are engaging; they indicated that museums would become 'charming places' if they made use of such games (study #1).

If the technologically mediated interactive experience promotes a fun and engaging tour, teenagers will be keen to share their **memories** of this tour through pictures and selfies on their social media networks (study #3).

IS A GAMIFIED EXPERIENCE IMPORTANT FOR A MUSEUM?

To answer this research question, I report on the studies with curatorship students (study #6) and CHPs (study #7), the initial focus groups showing teenagers' perspective on museums (study #1), and the study of design patterns from the designs of teenagers (study #3).

A gamified experience is important for a museum, as both curators and teenagers agree that it could be a powerful means of boosting teenagers' engagement, even if curators would ascribe more importance to story-based strategies, and teenagers to game-based ones. Moreover, it is crucial to make use of gamified experiences to display information that otherwise would not be displayed due to physical limitations.

Curators prefer to think about story-based gamified experiences and do not focus much attention on the type of technology that could be used (study #6). **Curators have knowledge** of the content that the gamified experience should display but they do not have technological skills.

It is essential for museums to incorporate the **interests of teenagers** into their gamified stories. Teenagers are interested in adding game mechanics into museum experiences (study #7) and are excited about experiencing technology in several ways (study #6). Furthermore, teenagers would add rewards to the museum experience (study #6). The experience could – and should – make use of technologies that provide digital rewards for visitors to take home.

From a museum's point of view, a gamified experience would be important when it provides visitors with a great amount of **appealing information** about the exhibits – information that could not be acquired without technological support. This information would be impactful enough to inspire teenagers to engage with it (study #7). Moreover, the inclusion of connections between teenagers and previous experiences and memories (gastronomy) is important, as it is positive and engaging (study #7). Also important is the inclusion of species' sounds and multimedia videos about them (studies #1, #3, #7).

IS A GAMIFIED EXPERIENCE ADEQUATE FOR A MUSEUM?

To answer this research question, I report on the studies of the evaluations of *Turning Point* (story-based strategy) and *Haunted Encounters* (game-based strategy) in approaches #1 and #2. A gamified experience is adequate for a museum when it inspires visitors to explore the premises and creates awareness among visitors about the content that the museum would like to convey. However, a gamified experience could use both game and storytelling techniques but at different degrees: a game-based strategy is centred on a game with storytelling as a background, and a story-based is centred on storytelling with elements of game mechanics. Different approaches can be implemented for different intentions depending on what museums want to highlight in an exhibition and the type of experience they want their visitors to have. A right solution would be to offer different experiences so that visitors pick what they feel is for them.

A gamified experience would encourage **competition** among teenagers in a group, as it would increase the element of challenge (approach #2). However, the experience should be carefully considered so that it does not end up promoting the experience as a game. A problem arises when visitors switch their focus from the museum experience to the mobile game and start running through the halls in search of the right exhibit, without looking at and enjoying the museum itself (approach #1). Competition in a museum is appropriate when visitors **explore** the museum carefully, learn about the exhibits, and progress through the experience without competing against others (approach #1). Furthermore, another issue is when visitors are so concerned about the technology and the competition that they cannot enjoy the museum (approach #1).

A gamified experience would be adequate for a museum when it facilitates **awareness** of the message that the museum wants to convey: their exhibits, scientific facts, or even stories related to the building (approach #2). The mechanics play an important role in fostering this awareness: if the exhibits are hard to find or are associated with more challenging questions, teenagers will remember them better (approach #2). However, this feature could overwhelm *Uncomfortable* visitors as they are not keen to take decisions or risks and feel inadequate.

Game-based strategies would facilitate exploration and awareness of selected exhibits through quizzes and game mechanics, while stories would facilitate awareness of historical facts and an understanding of their consequences, as well as of the messages that the museum would like to convey. It is up to museums and curators to choose which content they would like to deliver and which strategy they would like to pursue.

How can we gamify the current stories and knowledge in museums?

To address this question, I report on the studies done with CHPs (studies #6, #7) and the stages of the production of the mobile experiences *Haunted Encounters* and *Turning Point* (Chapter #4).

CHPs should be involved in the ideation of interactive tools as active players in the development of the technology design process, as they are responsible for shaping museum experiences and collections (studies #6, #7). **Co-design methods** and techniques are valuable for involving CHPs in this ideation, and are great ways to understand their attitudes and perspectives – in particular, their values, goals, and aspirations to create exhibitions (studies #6, #7). CHPs attach their importance to the story that the museum wants to convey, choosing to think of an experience as a whole without paying much attention to the type of technology that can be used (study #6). It is hard for CHPs to include the interests of teenagers within the tours, as they find it challenging to put themselves in teenagers' shoes (study #7). Here, a professional production team plays a vital role in harvesting these ideas and delivering them in the form of tangible and professional prototypes.

Professional experience production teams should then be involved with the museum to obtain an understanding of their concerns and messages so that they can create and deploy an exciting **museum experience targeted at teenagers**. The production teams should be involved at an early stage in meetings with CHPs to develop an understanding of the message and goals the museum would like to communicate to teenagers. Then, the team should take several museum tours to gain a perspective on the museum building and on the main species that the interactive experience should address (stage #1). The team should merge the message and facts that the museum wants to convey with the guidelines for engaging teenagers in museums and should start with the main idea for a story plot that grounds the gamified experience (stage #2). This story plot should be carefully thought out and aligned with the museum's goals (stage #3). Then, the mobile concepts should be developed and several internal meetings should be held to determine the best mechanics and strategies to adopt (stage #4). Next, the team should produce characters and backgrounds that will provide the body of the experience (stage #5). Finally, during the technical development stage, the team will implement the experience though tangible prototypes (stage #6). Concerning the educational and scientific content of the mobile approaches, it is now up to the NHMF and other museums the will to update their mobile approaches with different exhibits in order to have something novel

to provide to their visitors. Given the time needed to build a prototype for a museum, I would say that museums could update the content of their mobile experiences ever two years.

HOW DOES A DIGITAL STORYTELLING AND GAME-BASED APPROACH ENHANCE THE USER EXPERIENCE OF TEENAGE VISITORS IN A MUSEUM?

To address this question, I report on the evaluation of *Memories of Carvalhal's Palace* (approaches #1-2).

A story- and game-based approach incorporating requirements that derive directly from co-design sessions with teenagers can enhance the user experience of these. Technology and interactivity play a role in helping teenagers **explore** the museum to engage in a treasure-hunt, search for species, and challenge their knowledge (approach #2). These mobile approaches can prompt teenagers' awareness of species as they view those species (and do not remain stuck in the smartphone), see scientific facts displayed in the mobile device, and find the species to be challenging to encounter (approach #2).

Museum exploration, the act of walking through the museum in search of several species and locations, promotes curiosity in the user who relates the exhibits to his or her past experiences (approaches #1-2).

Additionally, teenagers would be more engaged if the mobile app displayed **information about more than 6 exhibits** (approach #2). Mobile tours should offer a considerable number of species to encounter. If the tour is too fast, it will not be engaging (approach #2).

On the one hand, story-based strategies, in which storytelling is prominent, should include an **engaging plot** well-crafted and highly edited (approaches #1-2). Moreover, excitement in the voices of the characters would promote awareness of the story plot (approach #2). On the other hand, game-based strategies, in which game mechanics predominate, would catch a visitor's attention by displaying challenging questions that promote **competition** (approach #2).

7.2. LIMITATIONS

I am aware of several shortcomings regarding the described work. It can be challenging: depending on others, the fact that school field trips are different from groups of friends, the teenagers in the samples not being from the same background, the co-design session being conducted in the teenage participants' normal classroom, the questionnaires being translated from English to Portuguese, and the applying of paper-based questionnaires. I describe these shortcomings in detail below.

Depending on others can be both a helpful and a harmful experience. I depended on the team I was leading to have the apps developed. The production phase and the technical implementation took more time than I expected. This situation led me to restructure my agenda, which cause a delay in the final user testing. Also, I depended on the schools and the teachers involved, and I did not know beforehand how many females and males would be involved in the testing. Moreover, unfortunately, when I planned the specific months for my studies, I knew the research would take place during the month of Easter; hence, there were two weeks during which I could not test, as it was Easter break. The final testing also depended on the weather conditions. The story-based approach, *Turning Point*, started in the garden, and at the time, the city was experiencing rain. Hence, at least once, a group of teenagers had to test the game-based approach (which did not make use of the garden) and not the story-based approach. Also, the NHMF was planning to close for reconstruction, but the staff did not know when that would happen. Therefore, I felt pressure to conduct the tests as quickly as possible. Fortunately, the museum did not close until one month after the user testing.

Although working with schools is a good way to acquire a number of teenage users, the experience of taking part in a school field trip will always be different from the experience of having teenagers willing to participate in the tour with their own groups of friends.

The fact that the participants were not all from the same school area background can be seen as problematic when one considers the results and collected data as one batch. However, I intended to approach not only teenagers from one single background but also teenagers from slightly different backgrounds, to gather general trends.

It is a significant limitation that the co-design sessions were conducted in the teens' regular classroom and that the participants were given only an oral introduction to the museum (though 90% of the participants had already visited the NHMF at some point in their lives).

Although all the questionnaires (MES, MGS, GEQ, PANAS) were applied to a different segment and were translated from English to the participants' mother tongue of Portuguese and then verified with an English professor to guarantee that the meaning was the same in both languages, the alignment of questionnaires items was not validated.

Another important limitation was the use of paper questionnaires (which, as a researcher, I learned to avoid whenever possible). Although paper questionnaires are more accessible to participants, the act of inserting all this data into SPSS can be a very burdensome and unproductive task for the researcher. In the MoCP's user testing, the 159 participants answered the questionnaires immediately after the experience. No computers or tablets with internet access were available to them, so they answered the questionnaires on a paper-pen basis. I understand that this was easier for them, as they did not have to wait for a computer to become available. Nevertheless, it was harder for me to insert all the data from the papers into SPSS. I spent a couple of days doing this, and I felt it was the most unproductive stage of my Ph.D. degree.

7.3. FUTURE WORK

In light of the above conclusions, here I detail long-term and short-term future research lines on the topic researched. Long-term research lines include using the 'framework' with teenagers and curators to co-design together concepts for mobile museum experiences and enable teen participation; the creation of ideation cards and the deployment of co-design workshops with museums and teenagers together with the use of these cards. Short-term research lines include the publishing of the studies conducted and the translation of scales not yet published.

I intend to use the guidelines from this thesis to develop 'ideation cards' that will help designers and cultural heritage professionals design mobile interactive solutions targeted at teenagers aged 15-19. Physical cards are a classic example of usability heuristics that match a system to the real world. Cards are typically used to display content and actions for a single piece of information – it is about providing relevant data and removing all the noise. In addition, cards promote the organization of an interface and create a design language within a more extensive system. When utilized correctly, they are a powerful way to express bite-sized content. The deployment of these cards is particularly essential when museums do not have access to teenagers for the implementation of co-design sessions.

Furthermore, it would also be interesting to gather together teenagers, museum experience designers and curators to develop, through the proposed 'framework' and also these 'ideation cards', museum experiences that would later be presented to designers, who themselves would put together the interaction to create usable prototypes. I believe that these co-design sessions would be exciting, as they would help museums partner with teenage visitors and include the teens' perspectives in the process of idea generation and product development.

Three studies reported in this document were not published in any conference nor journal, and I intend to publish the following:

- Study #4: '*Game mechanics & narrative plots*', a thematic analysis derived from co-design sessions with 155 teenage participants about how to enhance teenagers' mobile experiences.
- Approach #2: '*Differences between Turning Point and Haunted Encounters*', a thematic analysis from the interviews done to each of the 159 participants who toured the museum with one of the apps.

All the participants were Portuguese; hence the scales used were translated from English to Portuguese and deployed with a large sample of teenagers that could be validated and published for reference to others. The scales and the total of participants who answered them are the following:

- Total of 171 teenagers (Study #7, Approach #2):
    - Museum Experience Scale (Othman et al., 2011) [Appendix 14],
    - Multimedia Guide Scale (Othman et al., 2011) [Appendix 15].
- Total of 159 teenagers (Approach #2):
    - Game Experience Questionnaire (GEQ) (Poels et al., 2007) – the post-game module [Appendix 31].

REFERENCES

Aarseth, E. (2012). A Narrative Theory of Games. *Proceedings of the International Conference on the Foundations of Digital Games*, 129–133. https://doi.org/10.1145/2282338.2282365

Aarseth, E. J. (1997). *Cybertext: Perspectives on Ergodic Literature*. Johns Hopkins University Press.

Aarseth, E. J. (2004). Genre trouble: narrativism and the art of simulation. In N. Wardrip-Fruin & P. Harrigan (Eds.), *First Person: New Media as Story, Performance, and Game*. Cambridge: The MIT Press.

Abt, C. C. (1987). *Serious Games*. University Press of America.

Acoustiguide Group, E. (2014). *Acoustiguide Audio Tour: Company Profile - Acoustiguide*. http://www.acoustiguide.com/company-profile

Alborzi, H., Druin, A., Montemayor, J., Platner, M., Porteous, J., Sherman, L., Boltman, A., Taxén, G., Best, J., Hammer, J., Kruskal, A., Lal, A., Schwenn, T. P., Sumida, L., Wagner, R., & Hendler, J. (2000). Designing StoryRooms: Interactive Storytelling Spaces for Children. *Proceedings of the 3rd Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques*, 95–104. https://doi.org/10.1145/347642.347673

Amanda Lenhart. (2015, April 9). Teens, Social Media & Technology Overview 2015. *Pew Research Center: Internet, Science & Tech*. http://www.pewinternet.org/2015/04/09/teens-social-media-technology-2015/

Antoniou, A., & Lepouras, G. (2010). Modeling Visitors' Profiles: A Study to Investigate Adaptation Aspects for Museum Learning Technologies. *J. Comput. Cult. Herit.*, *3*(2), 7:1–7:19. https://doi.org/10.1145/1841317.1841322

Aurasma is now HP Reveal. (n.d.). Retrieved September 13, 2018, from https://www.aurasma.com/

Avram, G., & Maye, L. (2016). Co-designing Encounters with Digital Cultural Heritage. *Proceedings of the 2016 ACM Conference Companion Publication on Designing Interactive Systems*, 17–20. https://doi.org/10.1145/2908805.2908810

Bailey-Ross, C., Gray, S., Ashby, J., Terras, M., Hudson-Smith, A., & Warwick, C. (2016). Engaging the museum space: Mobilizing visitor engagement with digital content creation. *Digital Scholarship in the Humanities*, 689–708. https://doi.org/10.1093/llc/fqw041

Bakken, S. M., & Pierroux, P. (2015). Framing a topic: Mobile video tasks in museum learning. *Learning, Culture and Social Interaction*, *5*, 54–65. https://doi.org/10.1016/j.lcsi.2014.12.001

Barbieri, L., Bruno, F., & Muzzupappa, M. (2017). Virtual museum system evaluation through user studies. *Journal of Cultural Heritage*. https://doi.org/10.1016/j.culher.2017.02.005

Barton, J., & Kindberg, T. (2001). *The Cooltown User Experience*. HP Hewlett Packard.

Bath Goodlander, G. (2009). Fictional press releases and fake artifacts: How the Smithsonian American Art Museum is letting game players redefine the rules. *Proc. of Museums and the Web 2009*. Museums and the Web 2009, Indianapolis, USA.

Batson, L., & Feinberg, S. (2006). Game Designs that Enhance Motivation and Learning for Teenagers. *Electronic Journal for the Integration of Technology in Education 5*, 34–43.

Beale, K. (Ed.). (2011). *Museums at play : games, interaction and learning*. MuseumsEtc. https://repository.museumsiam.org/handle/6622252777/54

Belk, R. W. (1995). Collecting as luxury consumption: Effects on individuals and households. *Journal of Economic Psychology*, *16*(3), 477–490. https://doi.org/10.1016/0167-4870(95)98956-X

Bellotti, F., Berta, R., De Gloria, A., D'ursi, A., & Fiore, V. (2013). A Serious Game Model for Cultural Heritage. *J. Comput. Cult. Herit.*, *5*(4), 17:1–17:27. https://doi.org/10.1145/2399180.2399185

Berg, S., Taylor, A. S., & Harper, R. (2003). Mobile Phones for the Next Generation: Device Designs for Teenagers. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 433–440. https://doi.org/10.1145/642611.642687

Bernstein, S. (2008). *Where Do We Go From Here? Cpntinuing with the Web 2.0 at the Brooklyn Museum* (J. Trand & D. Bearman (Eds.); pp. 37–47). Archives & Museum Informatics.

Binsubaih, A., Maddock, S., & Romano, D. (2009). *Serious Games for the Police: Opportunities and Challenges*.

Birchall, D., Henson, M., Burch, A., Evans, D., & Goldman, K. (2012). *Levelling up: Towards best practice in evaluating museum games | museumsandtheweb.com*. Museums and the Web 2012, San Diego, USA.

Bitgood, S. (2009). Museum Fatigue: A Critical Review. *Visitor Studies*, *12*(2), 93–111. https://doi.org/10.1080/10645570903203406

Blanchard, K., & Cheska, A. T. (1986). The Anthropology of Sport : An Introduction. *L'Homme*, *26*(97), 393–394.

Blöckner, M., Danti, S., Forrai, J., Broll, G., & De Luca, A. (2009). Please Touch the Exhibits!: Using NFC-based Interaction for Exploring a Museum. *Proceedings of the 11th International Conference on Human-Computer Interaction with Mobile Devices and Services*, 71:1–71:2. https://doi.org/10.1145/1613858.1613943

Bogost, I. (2010). *Persuasive Games: The Expressive Power of Videogames*. The MIT Press.

Bossen, C., Dindler, C., & Iversen, O. S. (2012). Impediments to User Gains: Experiences from a Critical Participatory Design Project. *Proceedings of the 12th Participatory Design Conference: Research Papers - Volume 1*, 31–40. https://doi.org/10.1145/2347635.2347641

Brade, J., Lorenz, M., Busch, M., Hammer, N., Tscheligi, M., & Klimant, P. (2017). Being there again – Presence in real and virtual environments and its relation to usability and user experience using a mobile navigation task. *International Journal of Human-Computer Studies*, *101*, 76–87. https://doi.org/10.1016/j.ijhcs.2017.01.004

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Brooke, J. (1996). SUS: A quick and dirty usability scale. *Usability Evaluation in Industry*, 189–194. London: Taylor & Francis.

Brown, D. (2009). *The Da Vinci Code*. Anchor.

Bruner, J. S., & Haste, H. (Eds.). (2010). *Making Sense (Routledge Revivals): The Child's Construction of the World* (1 edition). Routledge.

Buur, J., & Matthews, B. (2008). Participatory Innovation: A Research Agenda. *Proceedings of the Tenth Anniversary Conference on Participatory Design 2008*, 186–189.

Buxton, B. (2007). *Sketching User Experiences: Getting the Design Right and the Right Design* (1 edition). Morgan Kaufmann.

Cabrera, J. S., Frutos, H. M., Stoica, A. G., Avouris, N., Dimitriadis, Y., Fiotakis, G., & Liveri, K. D. (2005). Mystery in the Museum: Collaborative Learning Activities Using Handheld Devices. *Proceedings of the 7th International Conference on Human Computer Interaction with Mobile Devices & Services*, 315–318. https://doi.org/10.1145/1085777.1085843

Cahill, C., Kuhn, A., Schmoll, S., Lo, W.-T., McNally, B., & Quintana, C. (2011). Mobile Learning in Museums: How Mobile Supports for Learning Influence Student Behavior. *Proceedings of the 10th International Conference on Interaction Design and Children*, 21–28. https://doi.org/10.1145/1999030.1999033

Cannell, M. (2015, March 17). Museums Turn to Technology to Boost Attendance by Millennials. *The New York Times*. http://www.nytimes.com/2015/03/19/arts/artsspecial/museums-turn-to-technology-to-boost-attendance-by-millennials.html

Cannell, M. (2017, December 21). Museums Turn to Technology to Boost Attendance by Millennials. *The New York Times*. https://www.nytimes.com/2015/03/19/arts/artsspecial/museums-turn-to-technology-to-boost-attendance-by-millennials.html

Capra, M., Radenkovic, M., Benford, S., Oppermann, L., Drozd, A., & Flintham, M. (2005). The Multimedia Challenges Raised by Pervasive Games. *Proceedings of the 13th Annual ACM International Conference on Multimedia*, 89–95. https://doi.org/10.1145/1101149.1101163

Carroll, J. M., & Rosson, M. B. (2007). Participatory design in community informatics. *Design Studies*, *28*(3), 243–261. https://doi.org/10.1016/j.destud.2007.02.007

Cesário, V. (2018). Analysing Texts and Drawings: The Teenage Perspective on Enjoyable Museum Experiences. *32nd British Human Computer Interaction Conference*, 1–3. https://doi.org/10.14236/ewic/HCI2018.215

Cesário, V. (2019). Guidelines for Combining Storytelling and Gamification: Which Features Would Teenagers Desire to Have a More Enjoyable Museum Experience? *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems*, SRC03. https://doi.org/10.1145/3290607.3308462

Cesário, V., Coelho, A., & Nisi, V. (2017a). An Unlikely Seamless Combination - Future Curators Designing Museum Experiences Towards the Desires of Actual Teenagers. *Proceedings of the 1st International Conference on Design and Digital Communication*, 101–109

Cesário, V., Coelho, A., & Nisi, V. (2019). Co-designing Gaming Experiences for Museums with Teenagers. In A. L. Brooks, E. Brooks, & C. Sylla (Eds.), *Interactivity, Game Creation, Design, Learning, and Innovation* (pp. 38–47). Springer International Publishing.

Cesário, V., Coelho, A., & Nisi, V. (2018a). Cultural Heritage Professionals Developing Digital Experiences Targeted at Teenagers in Museum Settings: Lessons Learned. *32nd British Human Computer Interaction Conference*, 1–12. https://doi.org/10.14236/ewic/HCI2018.58

Cesário, V., Coelho, A., & Nisi, V. (2018b). Design Patterns to Enhance Teens' Museum Experiences. *32nd British Human Computer Interaction Conference*, 1–5. https://doi.org/10.14236/ewic/HCI2018.160

Cesário, V., Coelho, A., & Nisi, V. (2017b). Teenagers as Experience Seekers Regarding Interactive Museums Tours. *Proceedings of the 1st International Conference on Design and Digital Communication*, 127–134.

Cesário, V., Matos, S., Radeta, M., & Nisi, V. (2017). Designing Interactive Technologies for Interpretive Exhibitions: Enabling Teen Participation Through User-Driven Innovation. *Human-Computer Interaction - INTERACT 2017*, 232–241. https://doi.org/10.1007/978-3-319-67744-6_16

Cesário, V., Radeta, M., Coelho, A., & Nisi, V. (2017). Shifting from the Children to the Teens' Usability: Adapting a Gamified Experience of a Museum Tour. *Human-Computer Interaction – INTERACT 2017*, 464–468. https://doi.org/10.1007/978-3-319-68059-0_52

Cesário, V., Radeta, M., Matos, S., & Nisi, V. (2017). The Ocean Game: Assessing Children's Engagement and Learning in a Museum Setting Using a Treasure-Hunt Game. *Extended Abstracts Publication of the Annual Symposium on Computer-Human Interaction in Play*, 99–109. https://doi.org/10.1145/3130859.3131435

Chang, T.-R., & Kaasinen, E. (2011). Three User-driven Innovation Methods for Co-creating Cloud Services. *Proceedings of the 13th IFIP TC 13 International Conference on Human-Computer Interaction - Volume Part IV*, 66–83.

Charitonos, K., Blake, C., Scanlon, E., & Jones, A. (2012). Museum learning via social and mobile technologies: (How) can online interactions enhance the visitor experience? *British Journal of Educational Technology*, *43*(5), 802–819. https://doi.org/10.1111/j.1467-8535.2012.01360.x

Chomutare, T., Tatara, N., Årsand, E., & Hartvigsen, G. (2013). Designing a diabetes mobile application with social network support. *Studies in Health Technology and Informatics*, *188*, 58–64.

Ciolfi, L., & McLoughlin, M. (2012). Designing for Meaningful Visitor Engagement at a Living History Museum. *Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design*, 69–78. https://doi.org/10.1145/2399016.2399028

Ciolfi, L., & Petrelli, D. (2016). *Walking and designing with cultural heritage volunteers | ACM Interactions*. 46–51.

Ciolfi, L., & Petrelli, D. (2015). Studying a Community of Volunteers at a Historic Cemetery to Inspire Interaction Concepts. *Proceedings of the 7th International Conference on Communities and Technologies*, 139–148. https://doi.org/10.1145/2768545.2768547

Coenen, T., Mostmans, L., & Naessens, K. (2013). MuseUs: Case Study of a Pervasive Cultural Heritage Serious Game. *J. Comput. Cult. Herit.*, *6*(2), 8:1–8:19. https://doi.org/10.1145/2460376.2460379

Collins, T. D., Mulholland, P., & Zdrahal, Z. (2008). Using mobile phones to map online community resources to a physical museum space. *International Journal of Web Based Communities*, *5*(1), 18–32. https://doi.org/10.1504/IJWBC.2009.021559

Cooper, P. (2007). *When Stories Come To School: Telling, Writing, & Performing Stories in the Early Childhood Classroom* (1st edition). Teachers & Writers Collaborative.

Čopič Pucihar, K., Kljun, M., & Coulton, P. (2016). Playing with the Artworks: Engaging with Art Through an Augmented Reality Game. *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, 1842–1848. https://doi.org/10.1145/2851581.2892322

Csikszentmihalyi, M. (1998). *Finding Flow: The Psychology of Engagement with Everyday Life* (Reprint edition). Basic Books.

Damala, A., Vaart, M. van der, Clarke, L., Hornecker, E., Avram, G., Kockelkorn, H., & Ruthven, I. (2016). Evaluating tangible and multisensory museum visiting experiences: Lessons learned from the meSch project. *Proc. of Museums and the Web 2016*. MW2016: Museums and the Web 2016.

Deterding, S., Björk, S. L., Nacke, L. E., Dixon, D., & Lawley, E. (2013). Designing Gamification: Creating Gameful and Playful Experiences. *CHI '13 Extended Abstracts on Human Factors in Computing Systems*, 3263–3266. https://doi.org/10.1145/2468356.2479662

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From Game Design Elements to Gamefulness: Defining "Gamification." *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments*, 9–15. https://doi.org/10.1145/2181037.2181040

Dickerson, J. C. (2013). *UX101: A Primer on User Experience Design* (1 edition). CreateSpace Independent Publishing Platform.

Dindler, C., Iversen, O. S., Smith, R., & Veerasawmy, R. (2010). Participatory Design at the Museum: Inquiring into Children's Everyday Engagement in Cultural Heritage. *Proceedings of the 22Nd Conference of the Computer-Human Interaction Special Interest Group of Australia on Computer-Human Interaction*, 72–79. https://doi.org/10.1145/1952222.1952239

Dini, R., Paternò, F., & Santoro, C. (2007). An Environment to Support Multi-user Interaction and Cooperation for Improving Museum Visits Through Games. *Proceedings of the 9th International Conference on Human Computer Interaction with Mobile Devices and Services*, 515–521. https://doi.org/10.1145/1377999.1378062

DiSalvo, B., Guzdial, M., Meadows, C., Perry, K., McKlin, T., & Bruckman, A. (2013). Workifying Games: Successfully Engaging African American Gamers with Computer Science. *Proceeding of the 44th ACM Technical Symposium on Computer Science Education*, 317–322. https://doi.org/10.1145/2445196.2445292

Djamasbi, S., Gomez, W., Kardzhaliyski, G., Liu, T., & Oglesby, F. (2013). App-Like Mobile Optimization and User Experience. *SIGHCI 2013 Proceedings*.

Djamasbi, S., & Wilson, V. (2017, January 4). MUX: Development of a Holistic Mobile User Experience Instrument. *Proceedings of the 50th Hawaii International Conference on System Sciences*.

Druin, A. (Ed.). (1998). *The Design of Children's Technology*. Morgan Kaufmann Publishers Inc.

Druin, A. (2002). The role of children in the design of new technology. *Behaviour & Information Technology*, *21*(1), 1–25. https://doi.org/10.1080/01449290110108659

Druin, A. (1999). Cooperative Inquiry: Developing New Technologies for Children with Children. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 592–599. https://doi.org/10.1145/302979.303166

Druin, A., Bederson, B. B., Hourcade, J. P., Sherman, L., Revelle, G., Platner, M., & Weng, S. (2001). Designing a Digital Library for Young Children. *Proceedings of the 1st ACM/IEEE-CS Joint Conference on Digital Libraries*, 398–405. https://doi.org/10.1145/379437.379735

Druin, A., Bederson, B., Boltman, A., Miura, A., Knotts-Callahan, D., & Platt, M. (1998). *The Design of Children's Technology* (A. Druin (Ed.); pp. 51–72). Morgan Kaufmann Publishers Inc. http://dl.acm.org/citation.cfm?id=303430.303435

Eagle, S. (2012). Learning in the early years: Social interactions around picturebooks, puzzles and digital technologies. *Computers & Education*, *59*(1), 38–49. https://doi.org/10.1016/j.compedu.2011.10.013

Eco, U. (2007). *Foucault's Pendulum* (1 edition). Mariner Books.

Edwards, S., & Schaller, D. (2007). The Name of the Game: Museums and Digital learning Elements. In H. Din & P. Hecht (Eds.), *The Digital Museum: A Think Guide* (First Edition). American Association of Museums.

Eladhari, M. P., & Mateas, M. (2008). Semi-autonomous Avatars in World of Minds: A Case Study of AI-based Game Design. *Proceedings of the 2008 International Conference on Advances in Computer Entertainment Technology*, 201–208. https://doi.org/10.1145/1501750.1501798

Engel, S. L. (2005). *Real Kids: Creating Meaning in Everyday Life*. Harvard University Press.

Ermi, L., & Mäyrä, F. (2005). Fundamental components of the gameplay experience: Analysing immersion. *In DIGRA Conference*

Falk, J. (2016). Museum audiences: A visitor-centered perspective. *Loisir et Société / Society and Leisure*, *39*(3), 357–370. https://doi.org/10.1080/07053436.2016.1243830

Falk, J. H. (2009). *Identity and the Museum Visitor Experience*. Routledge.

Falk, J. H., & Dierking, L. D. (1997). School Field Trips: Assessing Their Long-Term Impact. *Curator: The Museum Journal*, *40*(3), 211–218. https://doi.org/10.1111/j.2151-6952.1997.tb01304.x

Falk, J. H., & Dierking, L. D. (2000). *Learning from Museums: Visitor Experiences and the Making of Meaning*. AltaMira Press.

Falk, J. H., Moussouri, T., & Coulson, D. (1998). The Effect of Visitors ' Agendas on Museum Learning. *Curator: The Museum Journal*, *41*(2), 107–120. https://doi.org/10.1111/j.2151-6952.1998.tb00822.x

Farber, A., Druin, A., Chipman, G., Julian, D., & Somashekhar, S. (2002). How Young Can Our Design Partners Be? *In Proceedings of the 2002 Participatory Design Conference, (Malmo*, 272–276.

Farina, M. C., Toledo, G. L., & Corrêa, G. B. (2006). Colecionismo: uma perspectiva abrangente sobre o comportamento do consumidor. *SEMINÁRIOS EM ADMINISTRAÇÃO FEA-USP*, *9*.

Ferris, K., Bannon, L., Ciolfi, L., Gallagher, P., Hall, T., & Lennon, M. (2004). Shaping Experiences in the Hunt Museum: A Design Case Study. *Proceedings of the 5th Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques*, 205–214. https://doi.org/10.1145/1013115.1013144

Finstad, K. (2010). The Usability Metric for User Experience. *Interacting with Computers*, *22*(5), 323–327. https://doi.org/10.1016/j.intcom.2010.04.004

Fisher, K. E., Durrance, J. C., & Hinton, M. B. (2004). Information Grounds and the Use of Need-based Services by Immigrants in Queens, New York: A Context-based, Outcome Evaluation Approach. *J. Am. Soc. Inf. Sci. Technol.*, *55*(8), 754–766. https://doi.org/10.1002/asi.20019

Fitton, D., Bell, B., Read, J. C., Iversen, O., Little, L., & Horton, M. (2014). Understanding Teen UX: Building a Bridge to the Future. *CHI '14 Extended Abstracts on Human Factors in Computing Systems*, 79–82. https://doi.org/10.1145/2559206.2559232

Fitton, D., Read, J. C. C., & Horton, M. (2013). The Challenge of Working with Teens As Participants in Interaction Design. *CHI '13 Extended Abstracts on Human Factors in Computing Systems*, 205–210. https://doi.org/10.1145/2468356.2468394

Fleck, M., Frid, M., Kindberg, T., O'Brien-Strain, E., Rajani, R., & Spasojevic, M. (2002). From Informing to Remembering: Ubiquitous Systems in Interactive Museums. *IEEE Pervasive Computing*, *1*(2), 13–21. https://doi.org/10.1109/MPRV.2002.1012333

Futurelab. (2009). *Using Computer Games in the Classroom* [NFER Teacher Voice Omnibus February Survey]. Futurlab. https://www.nfer.ac.uk/pdf/futurelab.pdf

Fyfe, G. (2006). Sociology and the Social Aspects of Museums. In S. Macdonald (Ed.), *A Companion to Museums Studies* (pp. 33–49). Blackwell Publishing.

Gee, J. P. (2008). Learning and Games. In K. Salen (Ed.), *The Ecology of Games: Connecting Youth, Games, and Learning* (pp. 21–40). MIT Press, Cambridge, MA.

Ghiani, G., Paternò, F., Santoro, C., & Spano, L. D. (2009). UbiCicero: A location-aware, multi-device museum guide. *Interacting with Computers*, *21*(4), 288–303. https://doi.org/10.1016/j.intcom.2009.06.001

Gould, J. D., & Lewis, C. (1985). Designing for Usability: Key Principles and What Designers Think. *Commun. ACM*, *28*(3), 300–311. https://doi.org/10.1145/3166.3170

Greenbaum, J., & Kyng, M. (Eds.). (1992). *Design at Work: Cooperative Design of Computer Systems*. L. Erlbaum Associates Inc.

Guha, M. L., Druin, A., Chipman, G., Fails, J. A., Simms, S., & Farber, A. (2005). Working with Young Children As Technology Design Partners. *Commun. ACM*, *48*(1), 39–42. https://doi.org/10.1145/1039539.1039567

Hakkila, J., Alhonsuo, M., Virtanen, L., Rantakari, J., Colley, A., & Koivumaki, T. (2016). MyData Approach for Personal Health – A Service Design Case for Young Athletes.

Proceedings of the 2016 49th Hawaii International Conference on System Sciences (HICSS), 3493–3502. https://doi.org/10.1109/HICSS.2016.436

Hall, L., Hume, C., & Tazzyman, S. (2016). Five Degrees of Happiness: Effective Smiley Face Likert Scales for Evaluating with Children. *Proceedings of the The 15th International Conference on Interaction Design and Children*, 311–321. https://doi.org/10.1145/2930674.2930719

Hall, T., & Bannon, L. (2005). Co-operative design of children'sinteraction in museums: a case studyin the Hunt Museum. *CoDesign*, *1*(3), 187–218. https://doi.org/10.1080/15710880512331392362

Halter, E. (2006). *From Sun Tzu to Xbox: War and Video Games*. Thunder's Mouth Press.

Hansen, E. I. K., & Iversen, O. S. (2013). You Are the Real Experts!: Studying Teenagers' Motivation in Participatory Design. *Proceedings of the 12th International Conference on Interaction Design and Children*, 328–331. https://doi.org/10.1145/2485760.2485826

Hatpaz, B. (2016, January 22). *Virtual reality experience highlight of new Dali Museum show*. https://phys.org/news/2016-01-virtual-reality-highlight-dali-museum.html

Hawkey, R. (2004). *Learning with Digital Technologies in Museums, Science Centres and Galleries* (No. 9). NESTA Futurelab Research.

Helal, D., Maxson, H., & Ancelet, J. (2013). Lessons Learned: Evaluating the Whitney's Multimedia Guide. In N. Proctor & R. Cherry (Eds.), *MD: Museums and the Web*. Silver Spring.

Holmquist, L. E. (2004). User-driven Innovation in the Future Applications Lab. *CHI '04 Extended Abstracts on Human Factors in Computing Systems*, 1091–1092. https://doi.org/10.1145/985921.985995

Hornecker, E. (2008). "I don't understand it either, but it is cool" - visitor interactions with a multi-touch table in a museum. *2008 3rd IEEE International Workshop on Horizontal Interactive Human Computer Systems*, 113–120. https://doi.org/10.1109/TABLETOP.2008.4660193

Hornecker, E., & Ciolfi, L. (2019). *Human-Computer Interactions in Museums*. Morgan & Claypool Publishers.

Hornecker, E., Clarke, L., McDermott, F., & Avram, G. (2013). Challenges and opportunities faced by cultural heritage professionals in designing interactive exhibits. *NODEM Conference Proceedings 2013*.

Hsi, S. (2003). A study of user experiences mediated by nomadic web content in a museum. *Journal of Computer Assisted Learning*, *19*(3), 308–319. https://doi.org/10.1046/j.0266-4909.2003.jca_023.x

Hsi, S., & Fait, H. (2005). RFID Enhances Visitors' Museum Experience at the Exploratorium. *Commun. ACM*, *48*(9), 60–65. https://doi.org/10.1145/1081992.1082021

Huhtamo, E. (2002). On the Origins of the Virtual Museum. In *Museums in a Digital Age* (Ross Parry, pp. 121–135). Routledge.

Huizinga, J. (2016). *Homo Ludens: A Study of the Play-Element in Culture*. Angelico Press.

Hunicke, R., Leblanc, M., & Zubek, R. (2005). MDA: A Formal Approach to Game Design and Game Research. *Proceedings of the Challenges in Games AI Workshop*. Nineteenth National Conference of Artificial Intelligence.

Ioannidis, Y., Raheb, K. E., Toli, E., Katifori, A., Boile, M., & Mazura, M. (2013). One object many stories: Introducing ICT in museums and collections through digital storytelling. *2013 Digital Heritage International Congress (DigitalHeritage)*, *1*, 421–424. https://doi.org/10.1109/DigitalHeritage.2013.6743772

Isomursu, M., Isomursu, P., & Still, K. (2004). Capturing tacit knowledge from young girls. *Interacting with Computers*, *16*(3), 431–449. https://doi.org/10.1016/j.intcom.2004.04.004

Isomursu, M., Isomursu, P., & Still, K. (2003). Involving Young Girls in Product Concept Design. *Proceedings of the 2003 Conference on Universal Usability*, 98–105. https://doi.org/10.1145/957205.957223

Iversen, O. S., & Brodersen, C. (2008). Building a BRIDGE Between Children and Users: A Socio-cultural Approach to Child–Computer Interaction. *Cogn. Technol. Work*, *10*(2), 83–93. https://doi.org/10.1007/s10111-007-0064-1

Iversen, O. S., & Smith, R. C. (2012a). Connecting to Everyday Practices: experiences from the Digital Natives exhibition. In E. Giaccardi (Ed.), *Heritage and Social Media* (pp. 126–144). Routledge.

Iversen, O. S., & Smith, R. C. (2012b). Scandinavian Participatory Design: Dialogic Curation with Teenagers. *Proceedings of the 11th International Conference on Interaction Design and Children*, 106–115. https://doi.org/10.1145/2307096.2307109

Jemmali, C., Bunian, S., Mambretti, A., & El-Nasr, M. S. (2018). Educational Game Design: An Empirical Study of the Effects of Narrative. *Proceedings of the 13th International Conference on the Foundations of Digital Games*, 34:1–34:10. https://doi.org/10.1145/3235765.3235783

Jenkins, H. (2004). Game design as narrative architecture. In N. Wardrip-Fruin & P. Harrigan (Eds.), *First Person: New Media as Story, Performance, and Game*. Cambridge: The MIT Press.

Jones, J. (2017, February 2). The drop in museum visitors reveals a nation without aspiration or hope | Jonathan Jones. *The Guardian*. https://www.theguardian.com/artanddesign/jonathanjonesblog/2017/feb/02/drop-uk-museum-attendance

Jull, J. (2001). Games telling Stories? - A brief note on games and narratives. *Game Studies: The International Journal of Computer Game Research*, *1*(1).

Jung, C. G. (1969). *Studies in Word-association*. London, Routledge & K. Paul.

Kangas, E., & Kinnunen, T. (2005). Applying User-centered Design to Mobile Application Development. *Commun. ACM*, *48*(7), 55–59. https://doi.org/10.1145/1070838.1070866

Karin Danielsson, & Charlotte Wiberg. (2006). Participatory design of learning media: Designing educational computer games with and for teenagers. *Interactive Technology and Smart Education*, *3*(4), 275–291. https://doi.org/10.1108/17415650680000068

Katifori, A., Karvounis, M., Kourtis, V., Kyriakidi, M., Roussou, M., Tsangaris, M., Vayanou, M., Ioannidis, Y., Balet, O., Prados, T., Keil, J., Engelke, T., & Pujol, L. (2014). CHESS: Personalized Storytelling Experiences in Museums. In A. Mitchell, C. Fernández-Vara, & D. Thue (Eds.), *Interactive Storytelling* (pp. 232–235). Springer International Publishing. https://doi.org/10.1007/978-3-319-12337-0_28

Katterfeldt, E.-S., Zeising, A., & Schelhowe, H. (2012). Designing Digital Media for Teenaged Apprentices: A Participatory Approach. *Proceedings of the 11th International Conference on Interaction Design and Children*, 196–199. https://doi.org/10.1145/2307096.2307124

Kelly, L. (2007). *The Interrelationships between adult museum visitors' learning and their museum experiences* [Ph.D., University of Technology].

Kim, A. J. (2011). *Gamification 101: Design the Player Journey* [Design]. https://www.slideshare.net/amyjokim/gamification-101-design-the-player-journey

Klopfer, E., Osterweil, S., Salen, K., & others. (2009). Moving learning games forward. *Cambridge, MA: The Education Arcade*.

Klopfer, E., Perry, J., Squire, K., Jan, M.-F., & Steinkuehler, C. (2005). Mystery at the Museum: A Collaborative Game for Museum Education. *Proceedings of Th 2005 Conference on Computer Support for Collaborative Learning: Learning 2005: The Next 10 Years!*, 316–320. http://dl.acm.org/citation.cfm?id=1149293.1149334

Knudtzon, K., Druin, A., Kaplan, N., Summers, K., Chisik, Y., Kulkarni, R., Moulthrop, S., Weeks, H., & Bederson, B. (2003). Starting an Intergenerational Technology Design Team: A Case Study. *Proceedings of the 2003 Conference on Interaction Design and Children*, 51–58. https://doi.org/10.1145/953536.953545

Koushik, M., Lee, E. J., Pieroni, L., Sun, E., & Yeh, C.-W. (2010). Re-envisioning the Museum Experience: Combining New Technology with Social-Networking. *Entertainment Computing - ICEC 2010*, 248–253. https://doi.org/10.1007/978-3-642-15399-0_24

Labrune, J.-B., & Mackay, W. (2006). Telebeads: Social Network Mnemonics for Teenagers. *Proceedings of the 2006 Conference on Interaction Design and Children*, 57–64. https://doi.org/10.1145/1139073.1139092

Laurel, B. (1991). *Computers As Theatre*. Addison-Wesley Longman Publishing Co., Inc.

Lehn, D. V., & Heath, C. (2005). Accounting for new technology in museum exhibtions. *International Journal of Arts Management*, *7*(3), 11–21.

Livingstone, S., & Helsper, E. (2007). Gradations in digital inclusion: children, young people and the digital divide. *New Media & Society*, *9*(4), 671–696. https://doi.org/10.1177/1461444807080335

Lund, A. (2001). Measuring Usability with the USE Questionnaire.pdf | Usability | Questionnaire. *Scribd*, *Usability Interface*, 3–6.

Magennis, S., & Farrell, A. (2005). Teaching and learning activities: expanding the repertoire to support student learning. *In Emerging Issues in the Practice of University Learning and Teaching*.

Mancini, F., & Carreras, C. (2010). Techno-society at the service of memory institutions: Web 2.0 in museums. *Catalan Journal of Communication & Cultural Studies*, *2*(1), 59–76. https://doi.org/10.1386/cjcs.2.1.59_1

Mann, S., Moses, J., & Fisher, M. (2013). Catching Our Breath: Assessing Digital Technologies for Meaningful Visitor Engagement. *Exhibitionist*, *Fall*, 15–19.

Mannion, S., Sabiescu, A., & Robinson, W. (2016, April). *Innovate or stagnate: Disrupting the conventional audio guide*. MW2016: Museums and the Web 2016, USA.

Mantyjarvi, J., Paternò, F., Salvador, Z., & Santoro, C. (2006). Scan and Tilt: Towards Natural Interaction for Mobile Museum Guides. *Proceedings of the 8th Conference on Human-Computer Interaction with Mobile Devices and Services*, 191–194. https://doi.org/10.1145/1152215.1152256

Martin, J., & Trummer, C. (2005). Personalized Multimedia Information System for Museums and Exhibitions. *Intelligent Technologies for Interactive Entertainment*, 332–335. https://doi.org/10.1007/11590323_46

Martins, A. I., Rosa, A. F., Queirós, A., Silva, A., & Rocha, N. P. (2015). European Portuguese Validation of the System Usability Scale (SUS). *Procedia Computer Science*, *67*, 293–300. https://doi.org/10.1016/j.procs.2015.09.273

Marty, P. F., Mendenhall, A., Douglas, I., Southerland, S. A., Sampson, V., Kazmer, M., Alemanne, N., Clark, A., & Schellinger, J. (2013). The Iterative Design of a Mobile Learning Application to Support Scientific Inquiry. *Journal of Learning Design*, *6*(2), 41–66. https://doi.org/10.5204/jld.v6i2.124

Maye, L. A., Bouchard, D., Avram, G., & Ciolfi, L. (2017). Supporting Cultural Heritage Professionals Adopting and Shaping Interactive Technologies in Museums. *Proceedings of the 2017 Conference on Designing Interactive Systems*, 221–232. https://doi.org/10.1145/3064663.3064753

Maye, L. A., McDermott, F. E., Ciolfi, L., & Avram, G. (2014). Interactive Exhibitions Design: What Can We Learn from Cultural Heritage Professionals? *Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational*, 598–607. https://doi.org/10.1145/2639189.2639259

Melero, J., Hernández-Leo, D., & Manatunga, K. (2015). Group-based mobile learning: Do group size and sharing mobile devices matter? *Computers in Human Behavior*, *4*, 377–385. https://doi.org/10.1016/j.chb.2014.11.078

Mensch, L. M., & Mensch, P. van. (2010). From Disciplinary Control to Co-creation - Collecting and the Development of Museums as Praxis in the Nineteenth and Twentieth Century. In S. Petterson, M. Hagedorn-Saupe, & A. Weij (Eds.), *Encoraging Collections Mobility - a Way Forward for Museums in Europe* (pp. 33–53). Finnish National Gallery.

Merritt, E. (2016, March 1). *Introducing TrendsWatch 2016*.

Montola, M., Stenros, J., & Waern, A. (2009). *Pervasive Games: Theory and Design* (1 edition). CRC Press.

Muchinenyika, S. H., Weede, O., & Muyingi, H. N. (2014). Persuasive Souvenir. *Proceedings of the 13th Participatory Design Conference: Short Papers, Industry Cases, Workshop Descriptions, Doctoral Consortium Papers, and Keynote Abstracts - Volume 2*, 175–176. https://doi.org/10.1145/2662155.2662225

Mulholland, P., & Collins, T. (2002). Using digital narratives to support the collaborative learning and exploration of cultural heritage. *Database and Expert Systems Applications, 2002. Proceedings. 13th International Workshop on*, 527–531.

Muller, M. J. (2003). Participatory design: the third space in HCI. In J. A. Jacko & A. Sears (Eds.), *The Human-computer Interaction Handbook* (pp. 1051–1068). L. Erlbaum Associates Inc. http://dl.acm.org/citation.cfm?id=772072.772138

Murray, J. (2004). From Game-story to cyberdrama. In N. Wardrip-Fruin & P. Harrigan (Eds.), *First Person: New Media as Story, Performance, and Game*. Cambridge: The MIT Press.

Nack, F., & Waern, A. (2012). Mobile digital interactive storytelling—a winding path. *New Review of Hypermedia and Multimedia*, *18*(1–2), 3–9. https://doi.org/10.1080/13614568.2011.641418

Napoli, J., & Ewing, M. T. (2000). The Net Generation. *Journal of International Consumer Marketing*, *13*(1), 21–34. https://doi.org/10.1300/J046v13n01_03

Nicholson, S. (2015). *Peeking Behind the Locked Door: A Survey of Escape Room Facilities*. White paper.

Nilsson, T., Blackwell, A., Hogsden, C., & Scruton, D. (2016). Ghosts! A Location-Based Bluetooth LE Mobile Game for Museum Exploration. *arXiv:1607.05654 [Cs]*. http://arxiv.org/abs/1607.05654

Nilsson, T., Hogsden, C., Perera, C., Aghaee, S., Scruton, D., Lund, A., & Blackwell, A. F. (2016). Applying Seamful Design in Location-based Mobile Museum Applications. *ACM Trans. Multimedia Comput. Commun. Appl.*, *12*(4), 56:1–56:23. https://doi.org/10.1145/2962720

Nisi, V., Oakley, D. I., & Haahr, D. M. (2006). *Inner City Locative Media: Design and Experience of a Location- Aware Mobile Narrative for the Dublin Liberties Neighborhood* (Vol. 6).

Nisi, V., Wood, A., Davenport, G., & Oakley, I. (2004). Hopstory: An Interactive, Location-Based Narrative Distributed in Space and Time. *Technologies for Interactive Digital Storytelling and Entertainment*, 132–141. https://doi.org/10.1007/978-3-540-27797-2_18

Norman, D. (2013). *The Design of Everyday Things* (Revised and Expanded). Basic Books.

Norman, D. A. (2010). *Living with Complexity*. The MIT Press.

Norooz, L., Mauriello, M. L., Jorgensen, A., McNally, B., & Froehlich, J. E. (2015). BodyVis: A New Approach to Body Learning Through Wearable Sensing and Visualization. *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, 1025–1034. https://doi.org/10.1145/2702123.2702299

O'Hara, K., Kindberg, T., Glancy, M., Baptista, L., Sukumaran, B., Kahana, G., & Rowbotham, J. (2007). Collecting and Sharing Location-based Content on Mobile Phones in a Zoo Visitor Experience. *Computer Supported Cooperative Work (CSCW)*, *16*(1–2), 11–44. https://doi.org/10.1007/s10606-007-9039-2

Othman, M. K., Petrie, H., & Power, C. (2011). Engaging Visitors in Museums with Technology: Scales for the Measurement of Visitor and Multimedia Guide Experience. In P. Campos, N. Graham, J. Jorge, N. Nunes, P. Palanque, & M. Winckler (Eds.), *Human-Computer Interaction – INTERACT 2011* (pp. 92–99). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-23768-3_8

Paley, V. G. (2005). *A Child's Work: The Importance of Fantasy Play*. University of Chicago Press.

Papert, S. (1980). *Mindstorms: Children, Computers, and Powerful Ideas*. Basic Books, Inc.

Pierroux, P., Bannon, L., Walker, K., Hall, T., Kaptelinin, V., & Stuedahl, D. (2007). MUSTEL: Framing the Design of Technology-Enhanced Learning Activities for Museum Visitors. *Proceedings of the International Cultural Heritage Informatics Meeting (ICHIM07)*. International Cultural Heritage Informatics Meeting (ICHIM07), Toronto.

Pierroux, P., Krange, I., & Sem, I. (2011). Bridging contexts and interpretations: Mobile blogging on art museum field trips. *MedieKultur: Journal of Media and Communication Research*, *27*(50), 18. https://doi.org/10.7146/mediekultur.v27i50.2997

Poels, K., Kort, Y. A. W., & IJsselsteijn, W. A. (2007). *D3.3: Game Experience Questionnaire: development of a self-report measure to assess the psychological impact of digital games*. Technische Universiteit Eindhoven.

Poole, E. S., & Peyton, T. (2013). Interaction Design Research with Adolescents: Methodological Challenges and Best Practices. *Proceedings of the 12th International Conference on Interaction Design and Children*, 211–217. https://doi.org/10.1145/2485760.2485766

Preece, J., Sharp, H., & Rogers, Y. (2015). *Interaction Design: Beyond Human-Computer Interaction* (4 edition). Wiley.

Read, J. C. C., Horton, M., Iversen, O., Fitton, D., & Little, L. (2013). Methods of Working with Teenagers in Interaction Design. *CHI '13 Extended Abstracts on Human Factors in Computing Systems*, 3243–3246. https://doi.org/10.1145/2468356.2479657

Read, J. C., Horton, M., Fitton, D., Little, L., Beale, R., & Toth, N. (2013). On Being Cool: Exploring Interaction Design for Teenagers. *Proceedings of the 27th International BCS Human Computer Interaction Conference*, 10:1–10:10. http://dl.acm.org/citation.cfm?id=2578048.2578063

Read, J. C., & MacFarlane, S. (2006). Using the Fun Toolkit and Other Survey Methods to Gather Opinions in Child Computer Interaction. *Proceedings of the 2006 Conference on Interaction Design and Children*, 81–88. https://doi.org/10.1145/1139073.1139096

Read, J., Fitton, D., Cowan, B., Beale, R., Guo, Y., & Horton, M. (2011). Understanding and Designing Cool Technologies for Teenagers. *CHI '11 Extended Abstracts on Human Factors in Computing Systems*, 1567–1572. https://doi.org/10.1145/1979742.1979809

Read, J., Gregory, P., Macfarlane, S., Mcmanus, B., Gray, P., & Patel, R. (2002). An Investigation of Participatory Design with Children - Informant, Balanced and Facilitated Design. In Ed, P. Markopoulos, & M. Kersten-Tsikalkina (Eds.), *Interaction Design and Children* (pp. 53–64).

Read, J., Horton, M., & Mazzone, E. (2005). The Design of Digital Tools for the Primary Writing Classroom. *EdMedia'05*.

Reichheld, F. F. (2003, December 1). *The One Number You Need to Grow*. Harvard Business Review.

Reid, J., Hull, R., Cater, K., & Fleuriot, C. (2005). Magic Moments in Situated Mediascapes. *Proceedings of the 2005 ACM SIGCHI International Conference on Advances in Computer Entertainment Technology*, 290–293. https://doi.org/10.1145/1178477.1178529

Reynolds, R., Walker, K., & Speight, C. (2010). Web-based museum trails on PDAs for university-level design students: Design and evaluation. *Computers & Education*, *55*(3), 994–1003. https://doi.org/10.1016/j.compedu.2010.04.010

Rhee, B., & Choi, Y. (2015). Using Mobile Technology for Enhancing Museum Experience : Case Studies of Museum Mobile Applications in S. Korea. *International Journal of Multimedia and Ubiquitous Engineering*, *10*(6), 39–44.

Rigby, S., & Ryan, R. (2011). *Glued to Games: How Video Games Draw Us In and Hold Us Spellbound*. Praeger.

Risseeuw, M., Cavada, D., Not, E., Zancanaro, M., Marshall, M. T., Petrelli, D., & Kubitza, T. (2016). Authoring Augmented Digital Experiences in Museums. *Proceedings of the International Working Conference on Advanced Visual Interfaces*, 340–341. https://doi.org/10.1145/2909132.2926064

Ritterfeld, U., Cody, M., & Vorderer, P. (Eds.). (2009). *Serious Games: Mechanisms and Effects* (1 edition). Routledge.

Robertson, J., & Good, J. (2004). Children's Narrative Development Through Computer Game Authoring. *Proceedings of the 2004 Conference on Interaction Design and Children: Building a Community*, 57–64. https://doi.org/10.1145/1017833.1017841

Rojas, S. L., Oppermann, L., Blum, L., & Wolpers, M. (2014). Natural Europe Educational Games Suite: Using Structured Museum-data for Creating Mobile Educational Games. *Proceedings of the 11th Conference on Advances in Computer Entertainment Technology*, 6:1–6:6. https://doi.org/10.1145/2663806.2663841

Rollings, A., & Adams, E. (2003). *Andrew Rollings and Ernest Adams on Game Design*. New Riders.

Roussou, M., Katifori, A., Pujol, L., Vayanou, M., & Rennick-Egglestone, S. J. (2013). A Life of Their Own: Museum Visitor Personas Penetrating the Design Lifecycle of a Mobile Experience. *CHI '13 Extended Abstracts on Human Factors in Computing Systems*, 547–552. https://doi.org/10.1145/2468356.2468453

Roussou, M., Kavalieratou, E., & Doulgeridis, M. (2007). Children Designers in the Museum: Applying Participatory Design for the Development of an Art Education Program. *Proceedings of the 6th International Conference on Interaction Design and Children*, 77–80. https://doi.org/10.1145/1297277.1297292

Ruder, D. B. (2008, September 1). *The Teen Brain*. Harvard Magazine. https://harvardmagazine.com/2008/09/the-teen-brain.html

Ryan, M.-L., & Rebreyend, A.-L. (2013). From Narrative Games to Playable Stories. *Nouvelle revue d'esthétique*, *No 11*(1), 37–50.

Sacher, H., & Loudon, G. (2002). Uncovering the New Wireless Interaction Paradigm. *Interactions*, *9*(1), 17–23. https://doi.org/10.1145/503355.503364

Salen, K. (2007). Gaming Literacies: A Game Design Study in Action. *Journal of Educational Multimedia and Hypermedia*, *16*(3), 301–322.

Sánchez, I., Cortés, M., Riekki, J., & Oja, M. (2011). NFC-based Interactive Learning Environments for Children. *Proceedings of the 10th International Conference on Interaction Design and Children*, 205–208. https://doi.org/10.1145/1999030.1999062

Sanders, E. B.-N., & Stappers, P. J. (2008). Co-creation and the new landscapes of design. *CoDesign*, *4*(1), 5–18. https://doi.org/10.1080/15710880701875068

Sauro, J. (2015). SUPR-Q: A Comprehensive Measure of the Quality of the Website User Experience. *J. Usability Studies*, *10*(2), 68–86.

Sayre, S., & Wetterlund, K. (2008). The Social Life of Technology for Museum Visitors. *Visual Arts Research*, *34*(2), 85–94.

Scaife, M., Rogers, Y., Aldrich, F., & Davies, M. (1997). Designing for or Designing with? Informant Design for Interactive Learning Environments. *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems*, 343–350. https://doi.org/10.1145/258549.258789

Schaller, D., & Flagg, B. (2013). Playtesting PlanetMania: A Mobile Game for Museum Exhibits. In C. Williams, A. Ochsner, J. Dietmeier, & C. Steinkuehler (Eds.), *Proc. of Museums and the Web 2013*. ETC Press.

Schell, J. (2008). *The Art of Game Design: A book of lenses*. CRC Press.

Schneider, S. K., O'Donnell, L., Stueve, A., & Coulter, R. W. S. (2012). Cyberbullying, School Bullying, and Psychological Distress: A Regional Census of High School Students. *American Journal of Public Health*, *102*(1), 171–177. https://doi.org/10.2105/AJPH.2011.300308

Schwabe, G., Goth, C., & Frohberg, D. (2005). Does Team Size Matter in Mobile Learning? *Proceedings of the International Conference on Mobile Business*, 227–234. https://doi.org/10.1109/ICMB.2005.35

Segall, A., & Trofanenko, B. (2016). The Victoria and Albert Museum. In D. E. Clover, K. Sanford, L. Bell, & K. Johnson (Eds.), *Adult Education, Museums and Art Galleries* (pp. 53–63). SensePublishers. https://doi.org/10.1007/978-94-6300-687-3_5

Semper, R., & Spasojevic, M. (2002). The Electronic Guidebook: Using Portable Devices and a Wireless Web-based Network to Extend the Museum Experience. *Proceedings of Museums and the Web Conference*, 18–20.

Shaffer, D. W., Squire, K. R., Halverson, R., & Gee, J. P. (2005). Video Games and the Future of Learning. *Phi Delta Kappan*, *87*(2), 105–111. https://doi.org/10.1177/003172170508700205

Sherry, C. J. (2009). *Animal Rights: A Reference Handbook, 2nd Edition* (2 edition). ABC-CLIO.

Simon, N. (2010). *The Participatory Museum*. http://www.participatorymuseum.org/

Sintoris, C., Yiannoutsou, N., Ortega-Arranz, A., López-Romero, R., Masoura, M., Avouris, N., & Dimitriadis, Y. (2014, November 14). TaggingCreaditor: A tool to create and share content for location-based games for learning. *ResearchGate*. MLCIOS: Special Session "Mobile Learning in Cultural Institutions and Open Spaces", IMCL2014. https://doi.org/10.1109/IMCTL.2014.7011148

Song, Y. (2014). "Bring Your Own Device (BYOD)" for Seamless Science Inquiry in a Primary School. *Comput. Educ.*, *74*, 50–60. https://doi.org/10.1016/j.compedu.2014.01.005

Speaker, K. M., Taylor, D., & Kamen, R. (2004). Storytelling: Enhancing Language Acquisition in Young Children. *Education*, *125*(1), 3.

Star, S. L., & Griesemer, J. R. (1989). Institutional Ecology, `Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology,

1907-39. *Social Studies of Science*, *19*(3), 387–420. https://doi.org/10.1177/030631289019003001

Stenglin, M. K. (2004). *Packaging curiosities : towards a grammar of three-dimensional space* [Ph.D., Department of Linguistics].

Sung, Y.-T., Chang, K.-E., Hou, H.-T., & Chen, P.-F. (2010). Designing an electronic guidebook for learning engagement in a museum of history. *Computers in Human Behavior*, *26*(1), 74–83. https://doi.org/10.1016/j.chb.2009.08.004

Sung, Y.-T., Hou, H.-T., Liu, C.-K., & Chang, K.-E. (2010). Mobile guide system using problem-solving strategy for museum learning: a sequential learning behavioural pattern analysis. *Journal of Computer Assisted Learning*, *26*(2), 106–115. https://doi.org/10.1111/j.1365-2729.2010.00345.x

Sustar, H., Bowen, S., Dearden, A., Fisher, M., & Wolstenholme, D. (2013, January 28). Using popular culture to enable health service co-design with young people. *EAD*. Crafting the Future, Gothenburg, Sweden. http://www.craftingthefuture.se/

Sykes, E. R., Pentland, S., & Nardi, S. (2015). Context-aware Mobile Apps Using iBeacons: Towards Smarter Interactions. *Proceedings of the 25th Annual International Conference on Computer Science and Software Engineering*, 120–129. http://dl.acm.org/citation.cfm?id=2886444.2886463

Tallon, L., & Walker, K. (Eds.). (2008). *Digital Technologies and the Museum Experience - Handheld Guide and Other Media*. AltaMira Press. https://rowman.com/ISBN/9780759111219

Taxén, G. (2004). Introducing Participatory Design in Museums. *Proceedings of the Eighth Conference on Participatory Design: Artful Integration: Interweaving Media, Materials and Practices - Volume 1*, 204–213. https://doi.org/10.1145/1011870.1011894

Taxén, G., Bowers, J., Hellström, S.-O., & Tobiasson, H. (2004). Designing Mixed Media Artefacts for Public Settings. In F. Darses, R. Dieng, C. Simone, & M. Zacklad (Eds.), *Cooperative Systems Design. Scenario-Based Design of Collaborative Systems* (pp. 195–210). Amsterdam: IOS Press.

Toth, N., Little, L., Read, J., Guo, Y., Fitton, D., & Horton, M. (2012). Teenagers Talking About Energy: Using Narrative Methods to Inform Design. *CHI '12 Extended Abstracts on Human Factors in Computing Systems*, 2171–2176. https://doi.org/10.1145/2212776.2223771

Tzibazi, V. (2013). Participatory Action Research with young people in museums. *Museum Management and Curatorship*, *28*(2), 153–171. https://doi.org/10.1080/09647775.2013.776800

Vavoula, G., Sharples, M., Rudman, P., Meek, J., & Lonsdale, P. (2009). Myartspace: Design and evaluation of support for learning with multimedia phones between classrooms and museums. *Computers & Education*, *53*(2), 286–299. https://doi.org/10.1016/j.compedu.2009.02.007

Vines, J., Clarke, R., Wright, P., McCarthy, J., & Olivier, P. (2013). Configuring Participation: On How We Involve People in Design. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 429–438. https://doi.org/10.1145/2470654.2470716

Wakkary, R., Hatala, M., Muise, K., Tanenbaum, K., Corness, G., Mohabbati, B., & Budd, J. (2009). Kurio: A Museum Guide for Families. *Proceedings of the 3rd International Conference on Tangible and Embedded Interaction*, 215–222. https://doi.org/10.1145/1517664.1517712

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063–1070.

Watzman, S. (2003). Visual Design Principles for Usable Interfaces. In J. A. Jacko & A. Sears (Eds.), *The Human-computer Interaction Handbook* (pp. 263–285). L. Erlbaum Associates Inc. http://dl.acm.org/citation.cfm?id=772072.772092

Wikia. (2013). *Generation Z: A Look At The Technology And Media Habits Of Today's Teens*. http://www.prnewswire.com/news-releases/generation-z-a-look-at-the-technology-and-media-habits-of-todays-teens-198958011.html

Winterburn, N., Gregory, P., & Fitton, D. (2016). Designing Teenage Emotions with a Life of Their Own. In *Perspectives on HCI Research with Teenagers* (pp. 207–236). Springer, Cham. https://doi.org/10.1007/978-3-319-33450-9_9

Witcomb, A. (2003). *Re-Imagining the Museum: Beyond the Mausoleum*. Routledge.

Wright, C., Bacigalupa, C., Black, T., & Burton, M. (2008). Windows into Children's Thinking: A Guide to Storytelling and Dramatization. *Early Childhood Education Journal*, *35*(4), 363–369. https://doi.org/10.1007/s10643-007-0189-0

Xhembulla, J., Rubino, I., Barberis, C., & Malnati, G. (2014). Intrigue at the Museum: Facilitating Engagement and Learning through a Location-Based Mobile Game. *Proceedings of the International Conference on Mobile Learning 2014*.

Yarosh, S., Radu, I., Hunter, S., & Rosenbaum, E. (2011). Examining Values: An Analysis of Nine Years of IDC Research. *Proceedings of the 10th International Conference on Interaction Design and Children*, 136–144. https://doi.org/10.1145/1999030.1999046

Zimmerman, E. (2004). Narrative, interactivity, play, and games: four naughty concepts in need of discipline. In N. Wardrip-Fruin & P. Harrigan (Eds.), *First Person: New Media as Story, Performance, and Game*. Cambridge: The MIT Press.

APPENDIX

Appendix 1. Activity plan for the Junior University 2017

TITLE
Fazer Jogos & Somar Histórias
(Making Games & Adding Stories)

DESCRIPTION OF THE ACTIVITY ADVERTISED TO THE POTENTIAL PARTICIPANTS – it appears on the Junior University's website in Portuguese
If you are passionate about telling stories, or if you simply love to play games... why not join us by visiting a museum to tell its story through a game? The fate and plots that stories could take in the game have only one limit: your imagination! With the activity *Fazer Jogos & Somar Histórias* you will know not only the inside of a museum in Porto but also you will change your course within the museum: What game would you play to make your visit more attractive and exciting? The *Fazer Jogos & Somar Histórias'* team counts on you to transform your museum experience into the most entertaining one through games and stories!

Se és apaixonado por contar histórias, ou se simplesmente adoras jogar... porque não te alias connosco a um museu para contares a sua história através de um jogo? O destino e enredos que a história pode tomar no jogo só tem um limite: a tua imaginação! Com a atividade *Fazer Jogas & Somar Histórias* conhecerás por dentro um museu no porto: não só o seu conteúdo, como poder mudar o teu rumo dentro do museu: Que jogo jogarias para tornar a tua visita mais atrativa e interessante? A equipa *Fazer Jogos & Somar Histórias* conta contigo para transformar a tua experiência museológica mais divertida através de jogos e histórias!

SUMMARY DESCRIPTION OF THE PROPOSAL
This initiative was born from the Ph.D. project in Digital Media of Vanessa Cesário.
Museums are important spaces of knowledge, however not every museum makes use of the new technologies to capture the attention of their visitors, especially the younger ones.
This initiative in making museums more attractive spaces for a younger audience allies with this same younger audience with the purpose of verifying how and why young people would make these spaces more appealing.
The primary goal of this summer project is to create interactive experiences with the young participants for one particular museum. We will initially conduct a user-driven innovation session with them and afterward develop, test and deploy the experience in the gallery setting.
The event scheduling for the weeks is presented in the next pages.

Appendix 2. Event scheduling for the activity 'Fazer Jogos & Somar Histórias' in the Junior University 2017

Hours	**Week**	**Localizations**
Morning: 09:30am-12:30pm Afternoon: 02pm-06pm	July 3rd-7th July 10th-14th	1) FEUP 2) FEUP's Digital Laboratory 3) Museums: - Medicine - FEUP

Day	**Localization**	**Objective**
Monday	Morning: FEUP	- Expectations: What do participants expect from the week? - An introduction to the project: games and stories for a better visitor user experience (escape rooms). - Exploration of different types of games in response to Natural and Science Museums through examples of the literature. - Monitor splits the group into two teams. - Challenge to prompt creativity: 30 minutes to think and draw an experience for a natural history museum. - Each team pitches their experience. - Feedback. - Introduction to the museum to work with over the week.
	Afternoon: Museum	- Transportation to the museum. - Guided tour of the museum. - Taking pictures of the interesting exhibits (it might be possible to have 360º images). - Transportation to FEUP.
Tuesday	Morning: FEUP	- Each group will have two one-hour slots to develop games/stories based on specific objects in the museum. - Each team pitches their ideas to the group. - Feedback.
	Afternoon: FEUP	- Define the concept of the game which will be developed. - Start development, play, test and improve. - Each team pitches their improved version of the experience. - Feedback. Suggest next steps and alternative approaches.
Wednesday	Morning: FEUP's Digital Laboratory	- Know and experiment the several technologies and projects of the FEUP's Digital Laboratory to inspire the participants.
	Tarde: FEUP	- Teamwork to define the concept of the game which will be developed. Activities will investigate narrative, mechanics, format and medium. - Each team presents their experience to the group. - Feedback.
Thursday	Morning: FEUP	- Preparing the games for playtesting (drawings, print).
	Afternoon: FEUP	- Playtest with the group. - Feedback on the playtesting session. - Split tasks to the final deployment on Friday
Friday	All day: Museum	- Participants' transportation to the museum - Setup of the projects - Real user tests with the museum's visitors - Participants' transportation to the FEUP

Appendix 3. Consents delivered to the participants of 'Fazer Jogos & Somar Histórias'

Informação ao Participante de Investigação e Consentimento Informado

Título do Estudo: Fazer Jogos & Somar Histórias

Investigadores: Vanessa Cesário – Faculdade de Engenharia da Universidade do Porto (FEUP), Madeira Interactive Technologies Institute (M-ITI) +351 967 972 390, vanessa.cesario@m-iti.org
Prof. António Coelho (FEUP), Prof. Valentina Nisi (M-ITI)

Preâmbulo
Ao estar inscrito para a atividade "Fazer Jogos & Somar Histórias" da Universidade Júnior poderá fazer parte de um estudo de investigação que será levado a cabo pelo monitor da atividade, através da orientação de professores especialistas.

Objetivo do estudo
A iniciativa deste estudo nasce num projeto de doutoramento em Medias Digitais da FEUP que tem como objetivo tornar os museus espaços mais atrativos para públicos jovens. Esta atividade de verão alia-se a esse mesmo público jovem com o objetivo de averiguar como e porquê os jovens poderiam tornar estes espaços mais interessantes através da tecnologia.

Procedimento
Os participantes inscritos na atividade "Fazer Jogos & Somar Histórias" irão desenvolver vários trabalhos acompanhados ao longo da semana relativos à perceção dos jovens na criação de experiências interativas para museus de ciência e de história natural.

Confidencialidade
A confidencialidade dos dados será mantida das seguintes formas: os dados de cada participante serão guardados separadamente; esta declaração de consentimento estará mantida nas instalações do M-ITI e não será divulgada a terceiros. Ao aceitar participar neste estudo, também aceita que a sua informação recolhida durante a experiência seja objeto de análise e de futuras publicações científicas. Para proteger a privacidade de cada participante, ser-lhes-á atribuído um código e toda a informação recolhida sobre eles será gravada através deste código, não contendo nunca os seus nomes.

Direitos
O participante é livre de querer continuar a participar na atividade "Fazer jogos & Somar Histórias" sem fazer parte do estudo. A recusa em participar ou interrupção da participação não resultará em qualquer penalização, ou perda de eventuais benefícios ou direitos. Os investigadores poderão decidir, de forma fundamentada, interromper a participação de algum participante neste estudo. Caso se verifique esta situação, esta não resultará em qualquer penalização.

Esclarecimento de Dúvidas & Contactos
Se você tem dúvidas sobre este estudo, se desejar obter mais informações, ou desejar interromper a participação no estudo, entre em contato com o Investigador Principal em pessoa, por telefone ou e-mail. A informação de contato está disponível no início da primeira página deste documento.

Menores
Os menores (indivíduos com idade inferior a 18 anos) não podem legalmente dar o consentimento para participar em estudos de investigação. O consentimento deve ser dado pelo responsável legal do participante.

Ao assinar este documento, você confirma que leu a informação acima descrita sobre este estudo, e que todas as suas perguntas foram respondidas. Assim mesmo, você poderá fazer perguntas adicionais a qualquer momento durante o estudo, e mesmo após este ter terminado.
Ao assinar este documento, você concorda que o seu educando participe neste estudo de investigação.

_____ _____

ASSINATURA DO RESPONSÁVEL LEGAL DATA

_____
NOME DO MENOR

Autorização Opcional
Entendo que os investigadores podem querer usar fotografias e áudio por razões ilustrativas nas apresentações e publicações deste trabalho, para fins científicos ou educativos. Eu dou autorização para fazê-lo, desde que o nome e rosto do participante não apareçam.

Assine no lugar pretendido:
_____SIM _____NÃO

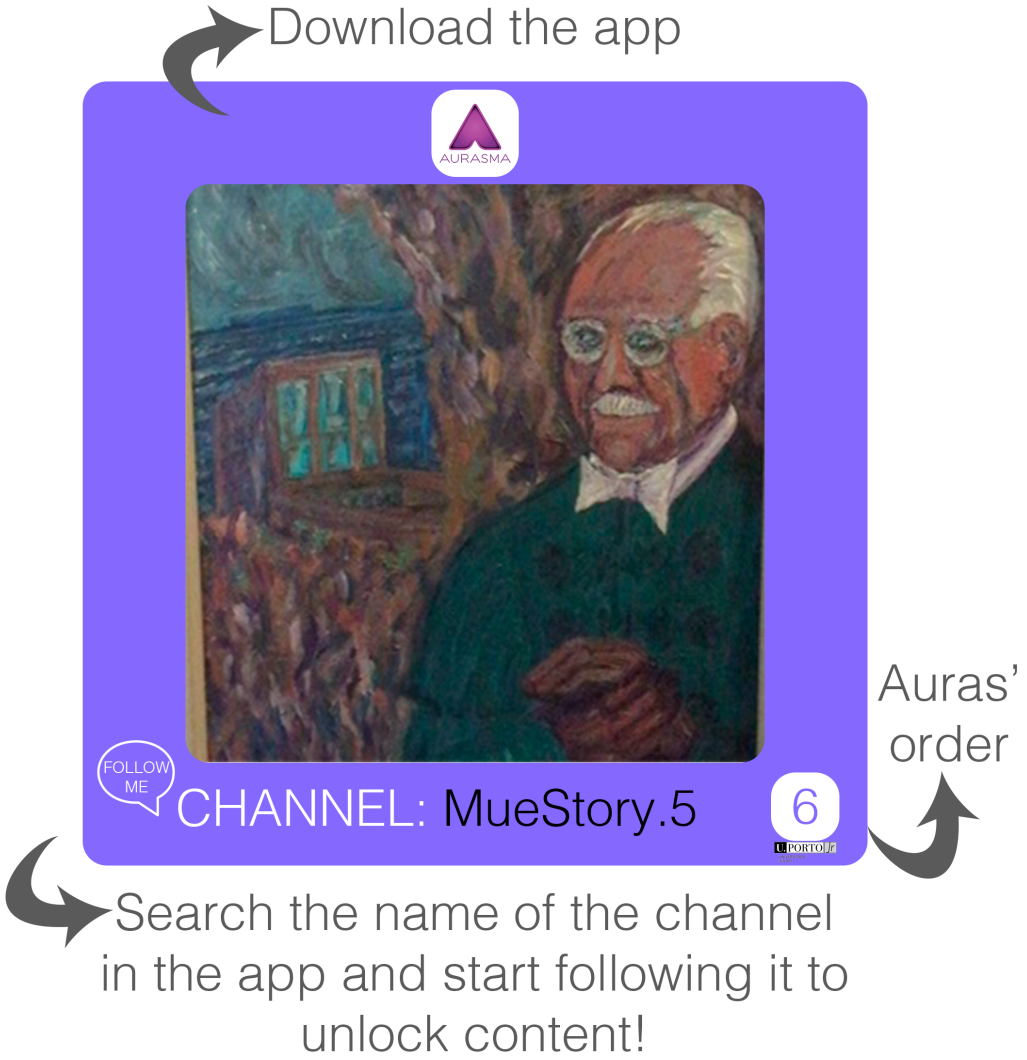
Investigador que Obtém o Consentimento
Como membro da equipa de investigação, confirmo que expliquei ao participante acima referido a natureza e finalidade deste estudo de investigação. Estou disponível para esclarecer quaisquer dúvidas que possam surgir ao longo do estudo.

_____ 27-06-2017
ASSINATURA DO INVESTIGADOR DATA

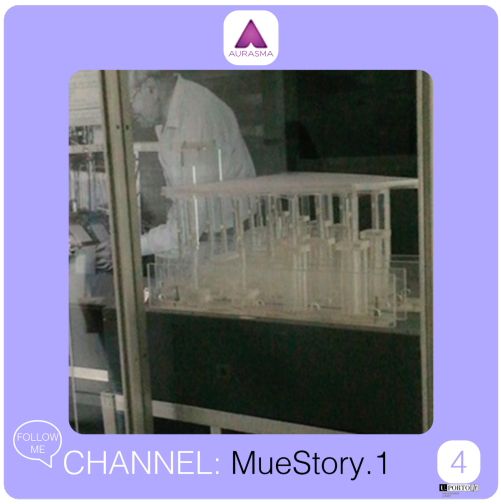
Appendix 4. Smiley Face Likerts – Five Degrees Of Happiness Metric delivered to the participants of 'Fazer Jogos & Somar Histórias'

Appendix 5. How to unlock the HP Reveal Experiences

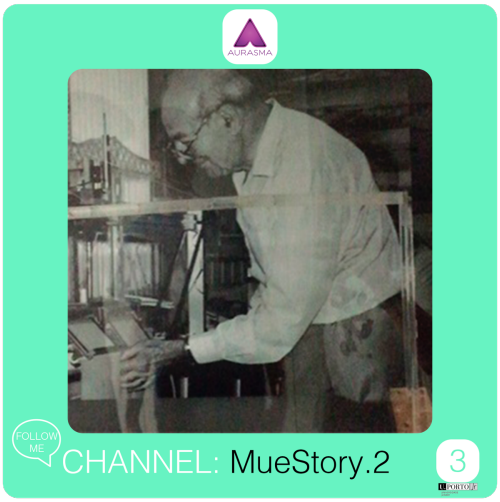
- **Print** the next labels
- **Download** Aurasma App
- **Search** and **Follow** the channels written in the labels scattered in the museum (each one is a different tour)
- **Catch** the images on the labels
- **Have fun** exploring the museum!



Appendix 6. HP Reveal labels to unlock the experience 'Bridge Builder'



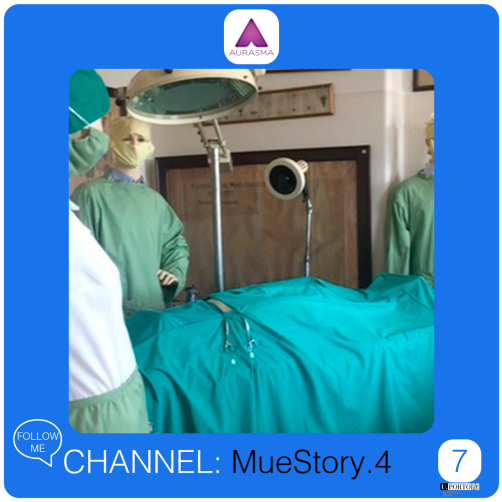
Appendix 7. HP Reveal labels to unlock the experience 'The Final Landing'



Appendix 8. HP Reveal labels to unlock the experience of 'Help the Doctor'*

*This channel is no longer available as the face of the children involved in the development of this prototype appeared in the videos displayed in each label.

Appendix 9. HP Reveal labels to unlock the experience of 'Medicine History'


AURASMA
FOLLOW ME
CHANNEL: MueStory.4
7

Appendix 10. HP Reveal labels to unlock the experience of 'Visiting the Medicine Museum'

Appendix 11. Statement from the Regional Secretary of Education from Madeira Island to carry out the co-design sessions with teenagers in their schools

S. R.

REGIÃO AUTÓNOMA DA MADEIRA
Governo Regional
SECRETARIA REGIONAL DE EDUCAÇÃO
DIREÇÃO REGIONAL DE EDUCAÇÃO

Direção Regional de Educação
GGAR

SAÍDA	PROCESSO(s)	DATA
Of: 645	5.67.0.0	27-03-2017

Exma. Senhora
Dra. Vanessa Quintal Cesário
vanessa.cesario@m-iti.org

ASSUNTO: **Autorização para realização de estudo em escolas da RAM**

Sobre o assunto em título, informa-se V. Excia de que o estudo foi autorizado pelo Diretor Regional de Educação, em 20-03-2017, uma vez que, submetido a análise, cumpre os requisitos, devendo atender-se às observações seguintes:

a) Respeitando o previsto no Decreto Legislativo Regional n.º 4/2000/M, de 31 de janeiro, alterado pelo Decreto Legislativo Regional n.º 21/2016, datado de 21 de junho, no qual estabelece o regime de autonomia, administração e gestão dos estabelecimentos de educação e de ensino público da Região Autónoma da Madeira, a realização do estudo em meio escolar fica sujeita à autorização dos Conselhos Executivos das Escola de 3.º ciclo do ensino básico e ensino secundário, a contactar para a sua realização. Merece especial atenção o modo, o momento e condições de aplicação dos instrumentos de recolha de dados em meio escolar, devendo fazer-se em estreita articulação com as direções das escolas.

b) Autorizada a realização do inquérito em meio escolar, pelos Conselhos Executivos das Escolas, fica ao critério de cada encarregado de educação autorizar ou não a participação dos seus educandos no estudo em questão e de cada estudante aceitar ou não participar na investigação.

c) Informa-se ainda que, de acordo com o diploma que aprovou a orgânica da Direção Regional de Educação (DRE) - Decreto Regulamentar Regional n.º 7/2016/M, de 5 de fevereiro – que estabelece as atribuições de âmbito pedagógico e didático no nível da educação pré-escolar, dos ensinos básico e secundário e educação extraescolar, a DRE não é competente para autorizar a realização de intervenções educativas/desenvolvimento de atividades/programas em meio escolar, junto de alunos em contexto de sala de aula, por ser suscetível de interferir no ato educativo, dado

Na resposta indicar a «Nossa Referência». Em cada ofício tratar só de um assunto

|| Rua D. João, n.º 57, Quinta Olinda • 9054-510 Funchal || Tel.: (+351) 291 705 860
|| www.madeira-edu.pt/dre • dre@live.madeira-edu.pt || NIPC: 671 000 497

S. R.

REGIÃO AUTÓNOMA DA MADEIRA
Governo Regional
SECRETARIA REGIONAL DE EDUCAÇÃO
DIREÇÃO REGIONAL DE EDUCAÇÃO

ser competência da Escola, a quem compete, também, nos termos do n.º 1 do Artigo 7.º do Decreto Legislativo Regional n.º 21/2013/M, de 28 de junho, salvaguardar o direito da confidencialidade dos dados pessoais dos alunos.

Com os melhores cumprimentos,

O Diretor de Serviços de Investigação,
Formação e Inovação Educacional
(Bernardo Lage Valério)

BV/LB

|| Rua D. João, n.º 57, Quinta Olinda • 9054-510 Funchal || Tel.: (+351) 291 705 860
|| www.madeira-edu.pt/dre • dre@live.madeira-edu.pt || NIPC: 671 000 497

Appendix 12. Consents delivered to the Cultural Heritage Professionals to be part of the training course

Informação ao Participante de Investigação e Consentimento Informado

Título do Estudo: Utilização de uma ferramenta de realidade aumentada para a construção de experiências interativas direcionadas aos jovens nos espaços museológicos

Investigador Principal: Vanessa Cesário
Madeira Interactive Technologies Institute & Faculdade de Engenharia da Universidade do Porto
Doutoranda em Medias Digitais
+351 967 972 390, vanessa.cesario@m-iti.org

Objetivo do Estudo
O objetivo principal desta investigação em formato de formação é dotar os participantes com competências teóricas, técnicas e práticas na criação de uma visita interativa para um espaço museológico específico.

Procedimento
Esta formação decorrerá no máximo total de 20h, seguindo o plano de trabalhos da folha em anexo. Durante a formação, o investigador irá tomar notas em relação aos trabalhos que serão desenvolvidos pelos participantes. Serão fornecidos 3 *smartphones*, 2 computadores e acesso à internet para a execução da formação. No final, todos serão convidados a uma entrevista privada, em horário a combinar, de forma a esclarecer eventuais questões por parte do investigador.

Critérios de Inclusão
Será considerado elegível para participar neste estudo se exercer uma função relacionada com o Museu de História Natural do Funchal e possuir conhecimentos básicos de informática na ótica do utilizador.

Benefícios
O benefício de participar neste estudo é dotar os participantes com competências teóricas, técnicas e práticas na criação de uma visita interativa para um espaço museológico específico. Esta formação pretende:
1) facultar conhecimentos teóricos sobre a divisão de audiências dentro dos espaços culturais;
2) facultar conhecimentos técnicos de como tornar um espaço museológico interativo com recurso a uma ferramenta de realidade aumentada (Aplicação *HP Reveal*) através de um *smartphone*;
3) proporcionar as competências práticas para explorar as diferentes potencialidades da aplicação de realidade aumentada com recurso à criação de narrativas e jogos desenvolvidas especificamente para um espaço cultural.

Custos
A participação nesta investigação não tem qualquer custo para o participante. No entanto, os participantes deverão deslocar-se ao Museu de História Natural do Funchal no horário estabelecido.

Confidencialidade
A confidencialidade dos dados será mantida das seguintes formas: os seus dados serão guardados separadamente; esta declaração de consentimento estará mantida nas instalações do Madeira Interactive Technologies Institute e não será divulgada a terceiros. Ao aceitar participar neste

estudo, também aceita que a sua informação recolhida durante a experiência seja objeto de análise e de futuras publicações científicas. Para proteger a sua privacidade, ser-lhe-á atribuído um código e toda a informação recolhida sobre si será gravada através deste código, não contendo nunca o seu nome.

Autorização

Assinale com um X qual das afirmações autoriza:

Entendo que os investigadores podem querer usar fotografias e áudio por razões ilustrativas nas apresentações e publicações deste trabalho, para fins científicos ou educativos.

[ ] Eu dou autorização para fazê-lo, desde que o meu **nome e rosto não** apareçam.
[ ] Eu dou autorização para fazê-lo, desde que o meu nome e rosto **apareçam**.
[ ] Eu dou autorização para fazê-lo, e podem usar o meu **nome**.
[ ] Eu dou autorização para fazê-lo, e podem utilizar fotos com o meu **rosto**.

Direitos

A sua participação é voluntária. Você é livre de interromper a sua participação em qualquer momento. A recusa em participar ou interrupção da participação não resultará em qualquer penalização, ou perda de eventuais benefícios ou direitos. O investigador principal poderá decidir, de forma fundamentada, interromper a sua participação neste estudo. Caso se verifique esta situação, esta não resultará em qualquer penalização, ou perda de eventuais benefícios ou direitos.

Esclarecimento de Dúvidas & Contactos

Se você tem dúvidas sobre este estudo, poderá fazer agora todas as perguntas. Se quiser fazer perguntas mais tarde, desejar obter mais informações, ou desejar interromper a sua participação no estudo, entre em contato com o Investigador Principal em pessoa, por telefone ou e-mail. A informação de contato está disponível no início da primeira página deste documento.

Investigador que Obtém o Consentimento

Como membro da equipa de investigação, confirmo que expliquei ao participante acima referido a natureza e finalidade deste estudo de investigação, e que esclareci quais os potenciais benefícios e eventuais riscos da participação no estudo. Todas as perguntas foram respondidas e estou disponível para esclarecer quaisquer dúvidas que possam surgir ao longo do estudo.

_____	19-02-2018
ASSINATURA DO INVESTIGADOR	DATA
_____	_____
ASSINATURA DO PARTICIPANTE	DATA

Appendix 13. Consents delivered to the teenagers to test the apps developed by the museum

Informação ao Participante de Investigação e Consentimento Informado

Título do Estudo: Utilização de uma ferramenta de realidade aumentada para a visita ao Museu de História Natural do Funchal

Investigador Principal: Vanessa Cesário
Madeira Interactive Technologies Institute & Faculdade de Engenharia da Universidade do Porto
Doutoranda em Medias Digitais
+351 967 972 390, vanessa.cesario@m-iti.org

Objetivo do Estudo
O objetivo principal desta investigação é avaliar como é que os jovens se sentem ao realizar visitas interativas construídas pelos funcionários do Museu de História Natural do Funchal (O Aquário).

Procedimento
A visita ao Museu de História Natural está programada para dia [XX/XX/XX] pelas [XX:XX], e terá a duração máxima de duas horas. Toda a deslocação entre a Escola [XX] e o Museu será coordenada pelo Prof. [XX].

Para esta visita:
- **Opcional**: Os alunos serão previamente convidados a fazer o *download* da aplicação **HP REVEAL** para o seu próprio telemóvel, deste modo poderão ter acesso aos conteúdos que irão aceder na visita.
- A turma será dividida em grupos de 3 ou 4 alunos;
- Será fornecido 1 *smartphone* por grupo e acesso à internet para a execução das visitas;
- Esclarecimentos em relação à aplicação interativa que será usada para guiar as visitas;
- Os grupos realizam, ao mesmo tempo, a visita interativa "Rota 1";
- Preenchimento de questionários em relação à "Rota 1";
- Os grupos realizam, ao mesmo tempo, a visita interativa "Rota 2";
- Preenchimento de questionários em relação à "Rota 2";
- Os grupos realizam, ao mesmo tempo, a visita interativa "Rota 3";
- Preenchimento de questionários em relação à Rota 3.

Critérios de Inclusão
Será considerado elegível para participar neste estudo se for estudante da Escola Secundária Francisco Franco e possuir entre os 15 e os 20 anos de idade.

Custos
A participação nesta investigação não tem qualquer custo para o participante. No entanto, os participantes deverão deslocar-se ao Museu de História Natural do Funchal no horário estabelecido pelo professor.

Confidencialidade
A confidencialidade dos dados será mantida das seguintes formas: os seus dados serão guardados separadamente; esta declaração de consentimento estará mantida nas instalações do *Madeira Interactive Technologies Institute* e não será divulgada a terceiros. Ao aceitar participar neste estudo, também aceita que a sua informação recolhida durante a experiência seja objeto de

análise e de futuras publicações científicas. Para proteger a sua privacidade, ser-lhe-á atribuído um código e toda a informação recolhida sobre si será gravada através deste código, não contendo nunca o seu nome.

Direitos
A sua participação é voluntária. Você é livre de interromper a sua participação em qualquer momento. A recusa em participar ou interrupção da participação não resultará em qualquer penalização, ou perda de eventuais benefícios ou direitos. O investigador principal poderá decidir, de forma fundamentada, interromper a sua participação neste estudo. Caso se verifique esta situação, esta não resultará em qualquer penalização, ou perda de eventuais benefícios ou direitos.

Autorização
Assinale com um **X** qual das afirmações autoriza:
Entendo que os investigadores possam querer usar fotografias e áudio por razões ilustrativas nas apresentações e publicações deste trabalho, para fins científicos ou educativos.

[ ] *Eu dou autorização para fazê-lo, desde que o* ***rosto do meu educando não*** *apareça.*
[ ] *Eu dou autorização para fazê-lo, desde que o* ***rosto do meu educando apareça****.*

Esclarecimento de Dúvidas & Contactos
Se você tem dúvidas sobre este estudo, poderá fazer agora todas as perguntas. Se quiser fazer perguntas mais tarde, desejar obter mais informações, ou desejar interromper a sua participação no estudo, entre em contato com o Investigador Principal em pessoa, por telefone ou e-mail. A informação de contato está disponível no início da primeira página deste documento.

Menores
Os menores (indivíduos com idade inferior a 18 anos) não podem legalmente dar o consentimento para participar em estudos de investigação. O consentimento deve ser dado pelo seu encarregado de educação.
Ao assinar este documento, você confirma que leu a informação acima descrita sobre este estudo, e que todas as suas perguntas foram respondidas. Você poderá também fazer perguntas adicionais a qualquer momento durante o estudo, e mesmo após este ter terminado. Ao assinar este documento, você concorda que o seu educando participe neste estudo de investigação.

_____ _____
ASSINATURA DO ENCARREGADO DE EDUCAÇÃO DATA

_____
NOME DO ALUNO

Investigador que Obtém o Consentimento
Como membro da equipa de investigação, confirmo que expliquei ao participante acima referido a natureza e finalidade deste estudo de investigação. Estou disponível para esclarecer quaisquer dúvidas que possam surgir ao longo do estudo.

_____ 02-05-2018
ASSINATURA DO INVESTIGADOR DATA

Appendix 14. Museum Experience Scale delivered to both CHPs and teenagers

Leia cada frase e faça um círculo na escala de acordo com o que sente.

Engagement / Envolvimento

Eu gostei de visitar a exposição.

1 **2** **3** **4** **5**
Discordo totalmente Concordo totalmente

Eu senti-me envolvido com a exposição.

1 **2** **3** **4** **5**
Discordo totalmente Concordo totalmente

A minha visita a esta exposição foi interessante.

1 **2** **3** **4** **5**
Discordo totalmente Concordo totalmente

Eu senti que estava a experienciar a exposição, em vez de apenas visitar o museu.

1 **2** **3** **4** **5**
Discordo totalmente Concordo totalmente

A minha visita a esta exposição foi inspiradora.

1 **2** **3** **4** **5**
Discordo totalmente Concordo totalmente

Conhecimento / Aprendizagem

A informação sobre as peças da exposição foi clara.

1 **2** **3** **4** **5**
Discordo totalmente Concordo totalmente

Eu consegui criar um significado sobre a maior parte das peças vistas na exposição.

1 **2** **3** **4** **5**
Discordo totalmente Concordo totalmente

Eu gostei dos gráficos associados a cada peça.

1 **2** **3** **4** **5**
Discordo totalmente Concordo totalmente

A minha visita enriqueceu o meu conhecimento e compreensão sobre peças específicas.

1 **2** **3** **4** **5**
Discordo totalmente Concordo totalmente

Eu descobri nova informação sobre as peças.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Meaningful Experience / Experiência Significativa

Durante a minha visita, fui capaz de refletir no significado e sentido das peças.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Durante a minha visita, tive de pensar muito (esforço) para poder refletir sobre a exposição.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Ver peças raras deu-me uma sensação de maravilha sobre a exposição.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Depois de visitar a exposição, eu ainda estava interessado em saber mais sobre o tópico da exposição.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Ver as peças (reais) expostas foi o mais gratificante ao fazer esta visita.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Emotional Connection / Conexão Emocional

A exposição permitiu-me relembrar o passado.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

O meu senso de estar na exposição foi mais forte do que o meu senso de estar no mundo real.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Fiquei impressionado com o aspeto estético / beleza das peças.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Eu gostaria de possuir peças como as que vi na exposição.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Eu senti-me conectado com as peças.

1	**2**	**3**	**4**	**5**
Discordo totalmente				Concordo totalmente

Appendix 15. Multimedia Guide Scale delivered to both CHPs and teenagers

General Usability / Usabilidade Geral

Vou usar um guia multimédia novamente quando visitar uma exposição.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Este guia multimédia foi uma distração.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

As informações fornecidas pelo guia multimédia eram muito longas.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Com o guia multimédia, foi difícil determinar onde é que eu estava na exposição.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

O guia multimédia ajudou-me a navegar pela exposição.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

A minha visita à exposição foi aprimorada pelo uso do guia multimédia.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

O guia multimédia foi complicado de usar.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Com o guia multimédia foi difícil de selecionar as opções que queria.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Learning and Control / Aprendizagem e controlo

Eu senti que estava a controlar o guia multimédia.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Aprender a usar o guia multimédia foi fácil.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Usar o guia multimédia não necessitou de muito treino.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Os controles do guia multimédia foram difíceis de perceber.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

O guia multimédia apresentou a informação de uma maneira clara.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Eu achei difícil de ler os textos no ecrã do guia multimédia.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Quality of the interaction with the guide / Qualidade de interação com o guia

O guia multimédia forneceu feedback sobre as minhas ações.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Foi claro para mim quando o guia multimédia estava tomando a iniciativa de me oferecer informações e quando eu precisava de pedir informações.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Fiquei inconsciente de que eu estava usando controles no guia multimédia.

1	2	3	4	5
Discordo totalmente				Concordo totalmente

Appendix 16. Positive and Negative Affect Schedule delivered to both CHPs and teenagers

Interessado				
1	**2**	**3**	**4**	**5**
Muito pouco/Nada	Um pouco	Moderadamente	Bastante	Extremamente
Angustiado				
1	**2**	**3**	**4**	**5**
Muito pouco/Nada	Um pouco	Moderadamente	Bastante	Extremamente
Animado				
1	**2**	**3**	**4**	**5**
Muito pouco/Nada	Um pouco	Moderadamente	Bastante	Extremamente
Chateado				
1	**2**	**3**	**4**	**5**
Muito pouco/Nada	Um pouco	Moderadamente	Bastante	Extremamente
Forte				
1	**2**	**3**	**4**	**5**
Muito pouco/Nada	Um pouco	Moderadamente	Bastante	Extremamente
Culpado				
1	**2**	**3**	**4**	**5**
Muito pouco/Nada	Um pouco	Moderadamente	Bastante	Extremamente
Assustado				
1	**2**	**3**	**4**	**5**
Muito pouco/Nada	Um pouco	Moderadamente	Bastante	Extremamente
Hostil (inimigo)				
1	**2**	**3**	**4**	**5**
Muito pouco/Nada	Um pouco	Moderadamente	Bastante	Extremamente
Entusiasmado				
1	**2**	**3**	**4**	**5**
Muito pouco/Nada	Um pouco	Moderadamente	Bastante	Extremamente
Orgulhoso				
1	**2**	**3**	**4**	**5**
Muito pouco/Nada	Um pouco	Moderadamente	Bastante	Extremamente

Irritado				
1	**2**	**3**	**4**	**5**
Muito pouco/Nada	Um pouco	Moderadamente	Bastante	Extremamente
Alertado				
1	**2**	**3**	**4**	**5**
Muito pouco/Nada	Um pouco	Moderadamente	Bastante	Extremamente
Envergonhado				
1	**2**	**3**	**4**	**5**
Muito pouco/Nada	Um pouco	Moderadamente	Bastante	Extremamente
Inspirado				
1	**2**	**3**	**4**	**5**
Muito pouco/Nada	Um pouco	Moderadamente	Bastante	Extremamente
Nervoso				
1	**2**	**3**	**4**	**5**
Muito pouco/Nada	Um pouco	Moderadamente	Bastante	Extremamente
Determinado				
1	**2**	**3**	**4**	**5**
Muito pouco/Nada	Um pouco	Moderadamente	Bastante	Extremamente
Atento				
1	**2**	**3**	**4**	**5**
Muito pouco/Nada	Um pouco	Moderadamente	Bastante	Extremamente
Nervoso/Frenético				
1	**2**	**3**	**4**	**5**
Muito pouco/Nada	Um pouco	Moderadamente	Bastante	Extremamente
Ativo				
1	**2**	**3**	**4**	**5**
Muito pouco/Nada	Um pouco	Moderadamente	Bastante	Extremamente
Receoso				
1	**2**	**3**	**4**	**5**
Muito pouco/Nada	Um pouco	Moderadamente	Bastante	Extremamente

Appendix 17. HP Reveal labels to unlock the experience of 'Discovering the Museum'*

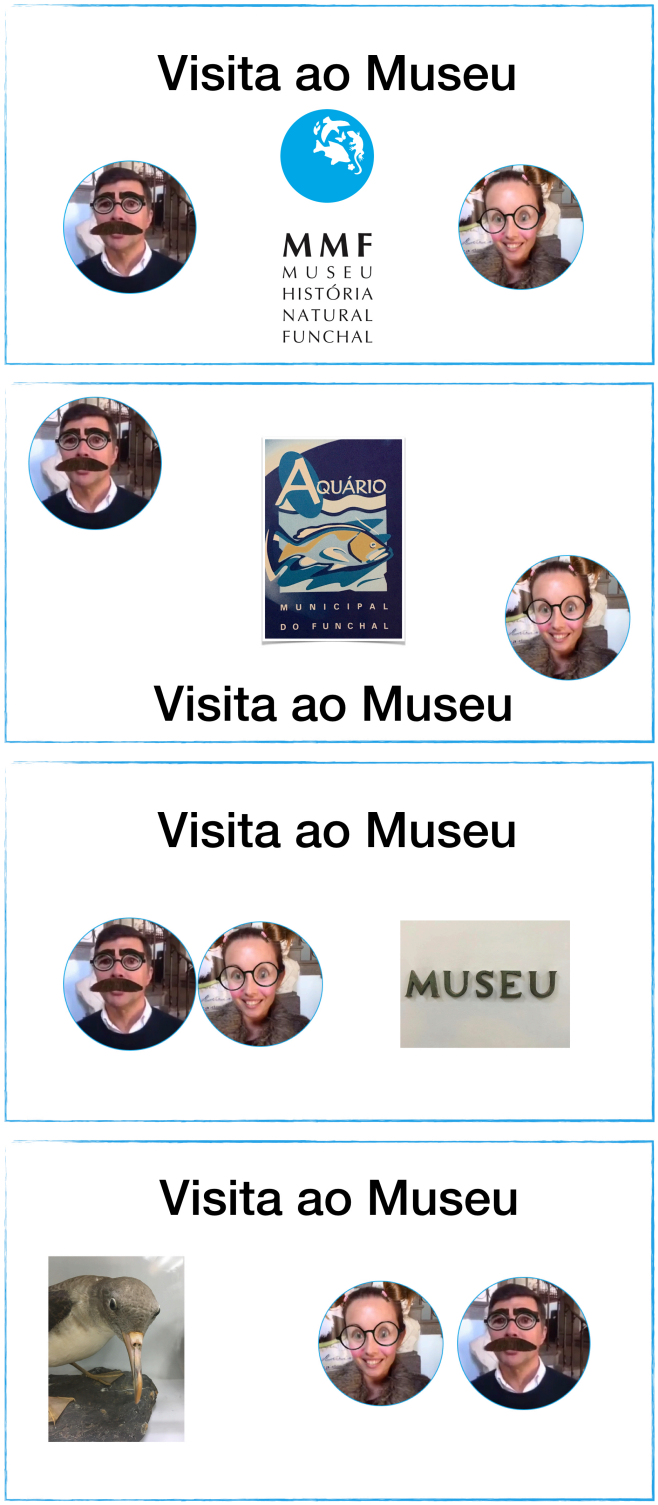
*This channel and its auras are no longer available as they were assembled in the HP Reveal Studio at the web, and on July 1st all accounts from this Studio were deactivated by HP Reveal.

Appendix 18. HP Reveal labels to unlock the experience of 'Gastronomic route'*

*This channel and its auras are no longer available as they were assembled in the HP Reveal Studio at the web, and on July 1st all accounts from this Studio were deactivated by HP Reveal.

Appendix 19. HP Reveal labels to unlock the experience of 'Visiting the Natural History Museum'*

*This channel and its auras are no longer available as they were assembled in the HP Reveal Studio at the web, and on July 1st all accounts from this Studio were deactivated by HP Reveal.



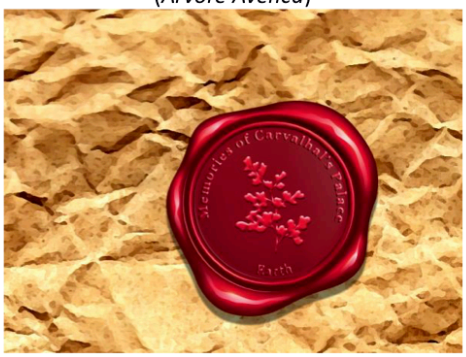
Appendix 20. Runes to unlock the *Turning Point* Experience

COMMON RUNES TO BOTH VERSIONS

Mimoca Pudica
(*Sensitiva*)

Lemon Balm
(*Erva Cidreira*)

Gingko Biloba
(*Árvore Avenca*)



Dragon tree
(*Dragoeiro*)

Fennel
(*Funcho*)

Til

Sugarcane
(*Cana de Açúcar*)

Flyingfish & Blowfish; Whale
(*Peixe-Voador* & *Peixe-Balão*; *Baleia*)

Dolphin
(*Golfinho*)

Heaven Act

XAVIER'S GOSSIPS

Sunfish
(*Peixe Lua*)

Monarch Butterfly
(*Borboleta Monarca*)

False Widow Spider
(*Falsa-Viúva-Negra*)

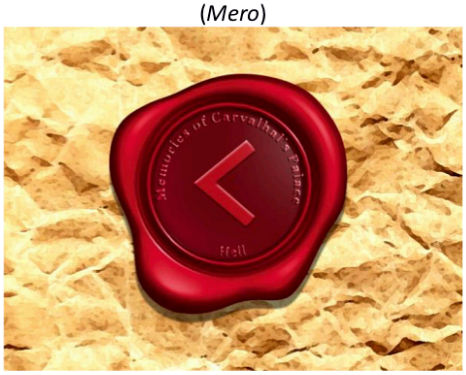
Crab
(*Caranguejo*)

Sea Bird Freira da Madeira
(*Pássaro marinho*)

Turtle
(*Tartaruga*)

MARINA'S GOSSIPS

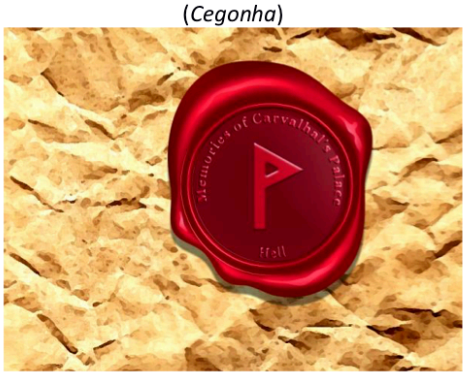
Dusky Grouper
(*Mero*)



Scabbard fish
(*Peixe-Espada*)

Turtle
(*Tartaruga*)

Stork
(*Cegonha*)



Seahorse
(*Cavalo-Marinho*)

Hammerhead Shark
(*Tubarão-Martelo*)

Appendix 21. Runes to unlock the *Haunted Encounters* Experience

RUNES FOR MEARA'S VERSION: SEA ANIMALS

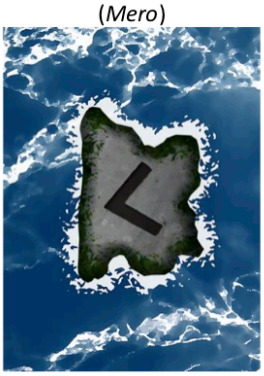
Sunfish
(*Peixe Lua*)

Hammerhead Shark
(*Tubarão-Martelo*)

Seahorse
(*Cavalo-Marinho*)

Monkseal
(*Lobo Marinho*)

Dusky Grouper
(*Mero*)



Blowfish
(*Peixe-Balão*)

RUNES FOR ISABEL'S VERSION: LAND ANIMALS

Stork
(*Cegonha*)

False-Widow-Spider
(*Aranha Falsa-Viúva-Negra*)

Monkseal
(*Lobo Marinho*)

Crab
(*Caranguejo*)

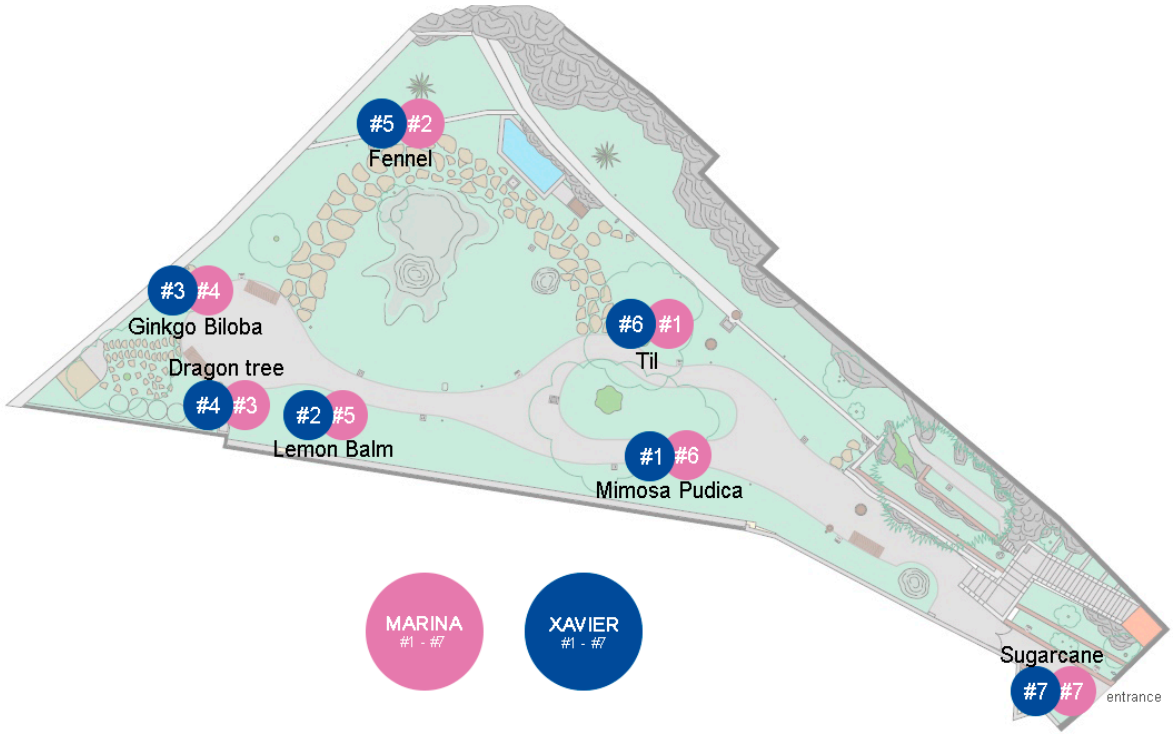
Sea Bird Freira da Madeira
(*Pássaro marinho*)

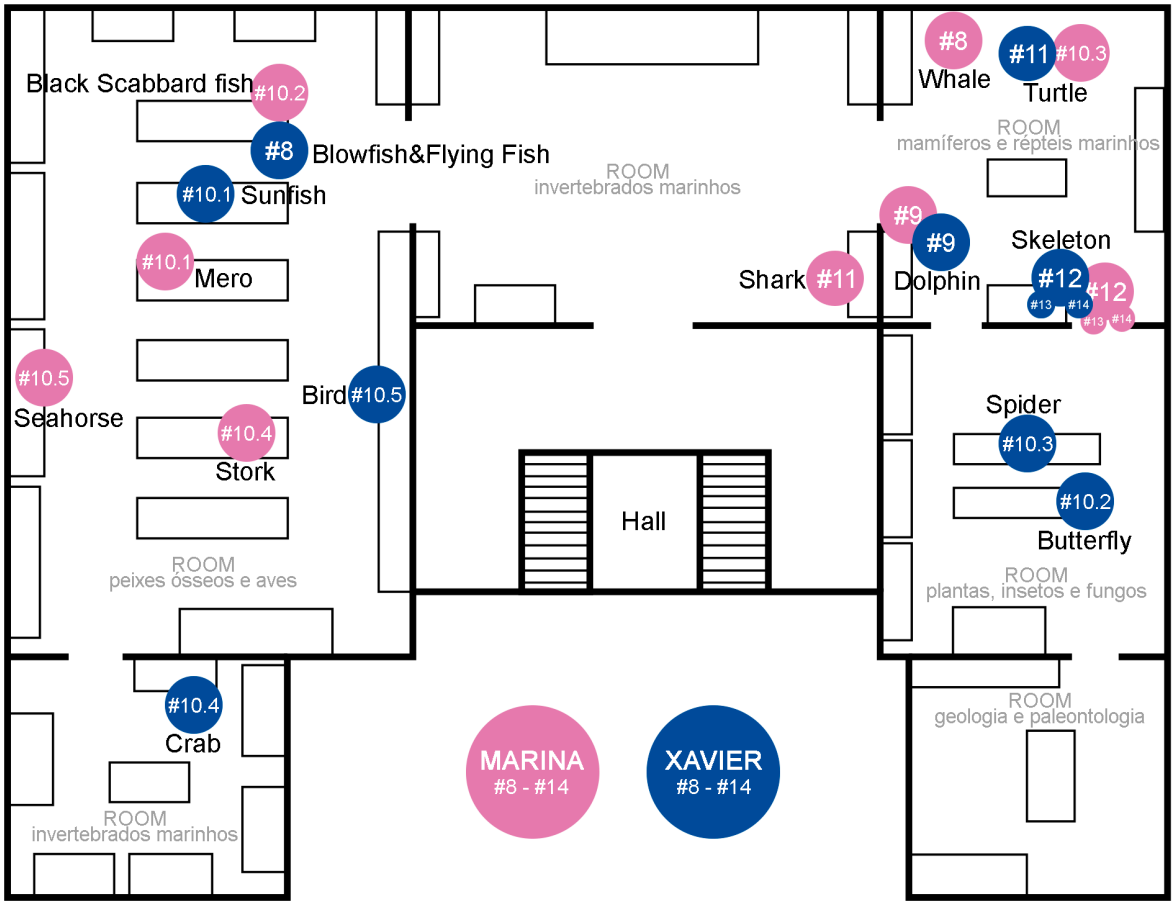
Monarch Butterfly
(*Borboleta Monarca*)

Appendix 22. Trajectory of the *Turning Point* experience

Narrative Act	Scene	Xavier's Point of view	Marina's Point of view	Points of interest (POIs)		Museum location	Structure: Linear or nonlinear
				Xavier	Marina		
Earth (9min)	1	**1789** Xavier and his father in the garden	**1789** Marina with her mother, at home in the garden	**Garden** – Mimosa Pudica (*Sensitiva*)	**Garden** - Til	#1	These 9 POIs are linear. Each one indicates the location of the next one.
	2	**1789** Out at sea	**1789** Meara's death	**Garden** – Lemon Balm (*Erva Cidreira*)	**Garden** – Fennel (*Funcho*)	#2	
	3	**1802** Xavier having breakfast with his mother Isabel	**1802** Marina with her father	**Garden** - Ginkgo Biloba (*Árvore Avenca*)	**Garden** – Dragon tree (*Dragoeiro*)	#3	
	4	**1802** How Esmeraldo died	**1802** Óscar and Isabel at Funchal Harbour	**Garden** – Dragon tree (*Dragoeiro*)	**Garden** – Ginkgo Biloba (*Árvore Avenca*)	#4	
	5	**1802** The day before the wedding, Xavier confronts his mother	**1802** Marina in the palace I	**Garden** – Fennel (*Funcho*)	**Garden** – Lemon Balm (*Erva Cidreira*)	#5	
	6	**1802** Wedding	**1802** Marina by the sea, on her wedding day	**Garden** - Til	**Garden** – Mimosa Pudica (*Sensitiva*)	#6	
	7	**1847** Xavier's death	**1809** Marina's death	**Garden** – Sugarcane (*Cana de Açúcar*)		#7	
Purgatory (4 min)	1	**1988** The ghost in the Palace	**1988** Marina in the palace II	Room #*Peixes Ósseos e Aves* near the **Blowfish** (*Peixe-Balão*) and the **Flying fish** (*Peixe-Voador*)	Room #*Mamíferos e Reptéis Marinhos*, near the **Whale** (*Baleia*)	#8	
	2	**1988** Bugio and the ghost	**1988** Bugio and Marina	Room #*Mamíferos e Reptéis Marinhos*, near the **Dolphin** (*Golfinho*)		#9	
Hell (4 min)	1	Gossip from the Sunfish	Gossip from the Mero	Room #*Peixes Ósseos e Aves* near the, near the **Sunfish** (*Peixe Lua*)	Room #*Peixes Ósseos e Aves* near the, near the **Dusky Grouper** (*Mero*)	#10.1	These 5 POIs are non-linear.
	2	Gossip from the Butterfly	Gossip from the scabbard fish	Room #*Plantas, Insetos e Fungos*, near the **Monarch Butterfly** (*Borboleta Monarca*)	Room #*Peixes Ósseos e Aves* near the, near the **Black Scabbard fish** (*Peixe-Espada Preto*)	#10.2	
	3	Gossip from the Spider	Gossip from the Turtle	Room #*Plantas, Insetos e Fungos*, near the **False Widow Spider** (*Aranha Falsa-Viúva-Negra*)	Room #*Mamíferos e Reptéis Marinhos*, near the **Turtle** (*Tartaruga*)	#10.3	

	4	Gossip from the Crab	Gossip from the White stork	Room #*Invertebrados Marinhos* near the **Jaca de Pau Crab** (Caranguejo Jaca de Pau)	Room #*Peixes Ósseos e Aves* near the near the **White stork** (*Cegonha Branca*)	#10.4	
	5	Gossip from the Sea bird	Gossip from the Seahorse	Room #*Peixes Ósseos e Aves* near the near the **Sea bird Freira da Madeira** (*Ave Marinha*)	Room #*Peixes Ósseos e Aves* near the near the **Seahorse** (*Cavalo-Marinho*)	#10.5	
	6	Gossip from the Turtle	Gossip from the Hammerhead shark	Room #*Mamíferos e Reptéis Marinhos*, near the **Turtle** (*Tartaruga*)	Room #*Peixes Cartilagíneos* near the **Hammerhead shark** (*Tubarão-Martelo*)	#11	These 3 POIs are linear. Each one indicates the location of the next one.
Heaven (3min)	1	**1988** Marina and Xavier		Room #*Mamíferos e Reptéis Marinhos*, near the **skeleton of a Sea Lion** (*Lobo Marinho*)		#12	
	2	**1988** Journal article				#13	
	3	Photo frame				*#14*	




Black Scabbard fish
#10.2
#8
Blowfish&Flying Fish
#10.1
Sunfish
#10.1
Mero
#10.5
Seahorse
Bird
#10.5
#10.4
Stork
ROOM
peixes ósseos e aves
#10.4
Crab
ROOM
invertebrados marinhos
ROOM
invertebrados marinhos
Hall
MARINA
#8 - #14
XAVIER
#8 - #14
#8
Whale
#11
#10.3
Turtle
ROOM
mamíferos e répteis marinhos
#9
#9
Dolphin
Shark
#11
Skeleton
#12
#13
#14
#12
#13
#14
Spider
#10.3
#10.2
Butterfly
ROOM
plantas, insetos e fungos
ROOM
geologia e paleontologia

Appendix 23. Trajectory of the *Haunted Encounters* experience

<table>
<tr><td colspan="2">Logo splash
+
Profile
Team name
Number of players
Picture of the team</td></tr>
<tr><td colspan="2">Introduction

Welcome to this palace!
They say that at night there are strange noises around here. Doors open and close, we feel cold, hear steps…
They say that all of this is linked to two women.</td></tr>
<tr><td>Meara</td><td>Isabel</td></tr>
<tr><td><u>Marine animals</u>
Meara introduces her worries

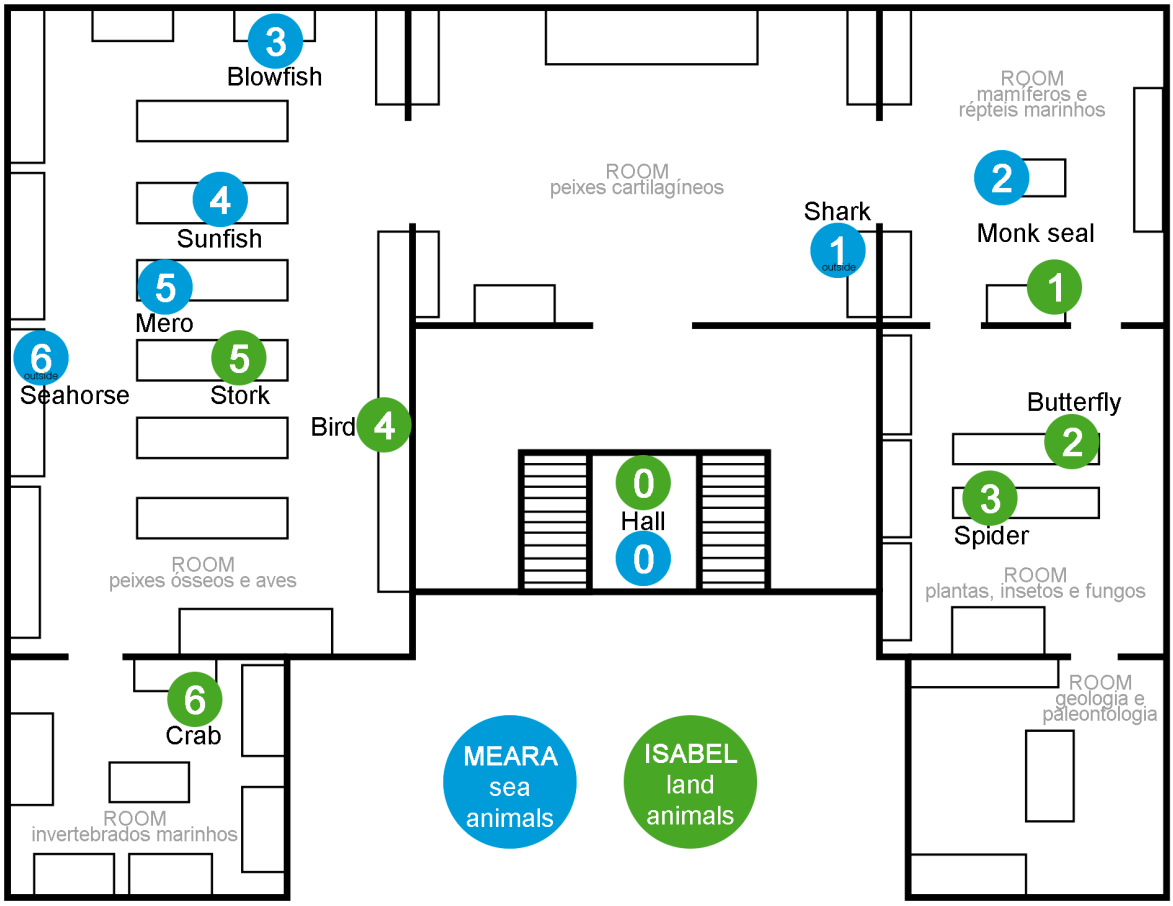
I am worried about my ocean friends. They tell me that there’s an evil presence at night that haunts the… I need to help them uncover this mystery!</td><td><u>Land animals</u>
Isabel introduces her worries

This is my house, or was in the past... I don’t know what happened. There are people around, that shouldn’t be here! Help me solve this mystery so I can be at peace again.</td></tr>
<tr><td colspan="2">Tutorial
Aim: find species, earn points and complete a map to know the specific location to solve the mystery</td></tr>
<tr><td colspan="2">Species to find by their shadows appearing on the screen
(non-linear)
Each shadow is accompanied with:
- a clue to find it
- help: 1) its localization; 2) a detail of the animal

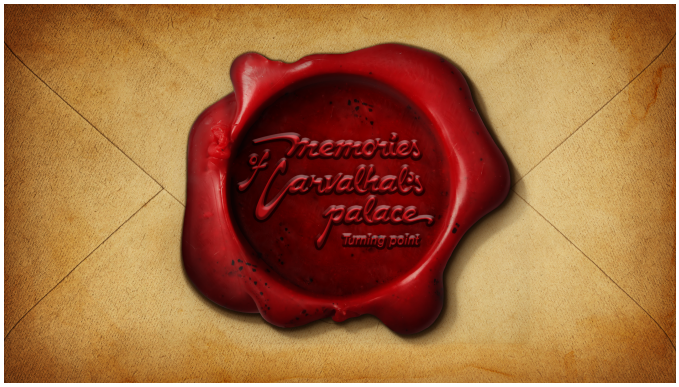
When found, user will be provided with:
- 1 question about the species
- a scientific curiosity</td></tr>
<tr><td>Monkseal
Shark
Blowfish
Sunfish
Dusky Grouper
Seahorse</td><td>Monkseal
Butterfly
Spider
Bird
Stork
Crab</td></tr>
<tr><td colspan="2">Message when the map is unlocked
Players need to go to the library and find a chest with a code inside

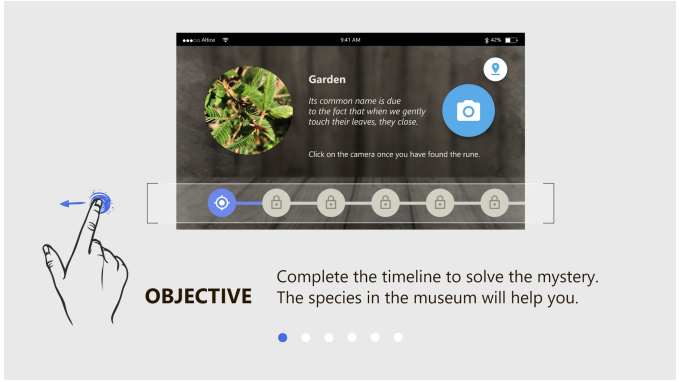
Find an open the treasure chest with the code to solve the mystery!</td></tr>
</table>

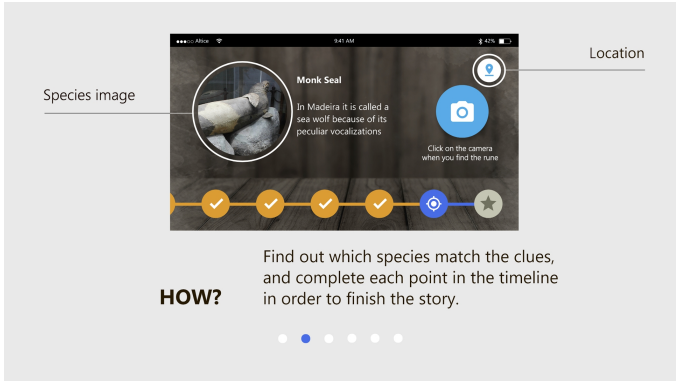
Library	
Ghost hunter (GPS coordinates) *Attention! New activity registered.* *Use the camera to know if there are any ghosts here* When they find it, it will appear a short animation of the Xavier's ghost	**Soul collector (radar)** *Attention! New activity registered.* *Use the camera to find how many souls are here with you* It will appear an animation of a radar, the sound of this radar will increase, and then a short animation of the Isabel's ghost
Mystery unlocked Meara appears *MYSTERY SOLVED, GOOD JOB.* *Turns out it is a ghost that is tormenting my marine friends. I'll have to find why he is doing it…* Button: Click to get reward	**Loss of Points** Isabel appears with a malefic look and players will lose their points (players are betrayed) *MYSTERY SOLVED* *At the beginning, I said that I didn't like the people that come through my palace. Why did you choose me?*
Photo and sharing Appears they first pic with the ghost on the cover and their ranking. These covers will be different regarding their punctuation (gold, silver, bronze) Button: Click to get the book you made	**GAME OVER** *Your points were stolen. Do you want to make amends and recover them?* *YES|NO** *if "no" is chosen, the players are directed for the photo sharing and book.
Book Appears the animation of the book (cover and pages about the species encountered) to be sent to their email	**YES** It appears one question about the museum. If participants correctly answer it, they will recover the points lost.
–	**Photo and sharing** Appears they first pic with the ghost on the cover and their ranking. These covers will be different regarding their punctuation (gold, silver, bronze) Button: Click to get the book you made
–	**Book** Appears the animation of the book (cover and pages about the species encountered) to be sent to their email

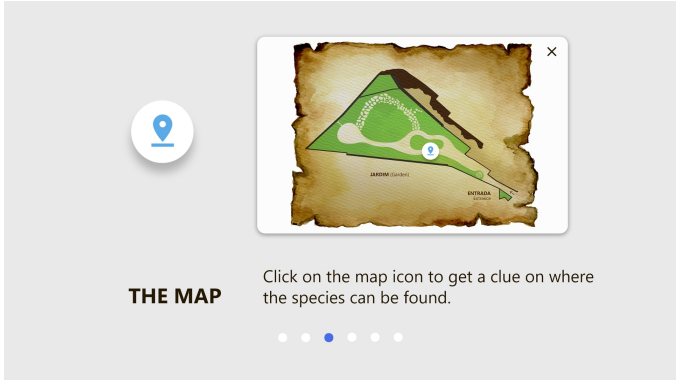

3
Blowfish
4
Sunfish
5
Mero
6
outside
Seahorse
5
Stork
Bird
4
ROOM
peixes ósseos e aves
6
Crab
ROOM
invertebrados marinhos
ROOM
peixes cartilagíneos
0
Hall
0
MEARA
sea
animals
ISABEL
land
animals
Shark
1
outside
ROOM
mamíferos e
répteis marinhos
2
Monk seal
1
Butterfly
2
3
Spider
ROOM
plantas, insetos e fungos
ROOM
geologia e
paleontologia

Appendix 24. Tutorial of the *Turning Point* experience









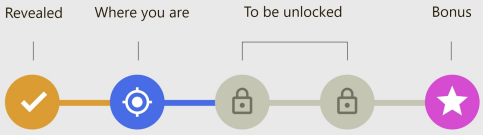
Click on the camera icon when you have found the species' rune.

FIND THE RUNES *

(*) Of nordic origin, they were used as charms due to its deeper meanings. Rune can mean "secret" or "something hidden".

FOLLOW THE STORY

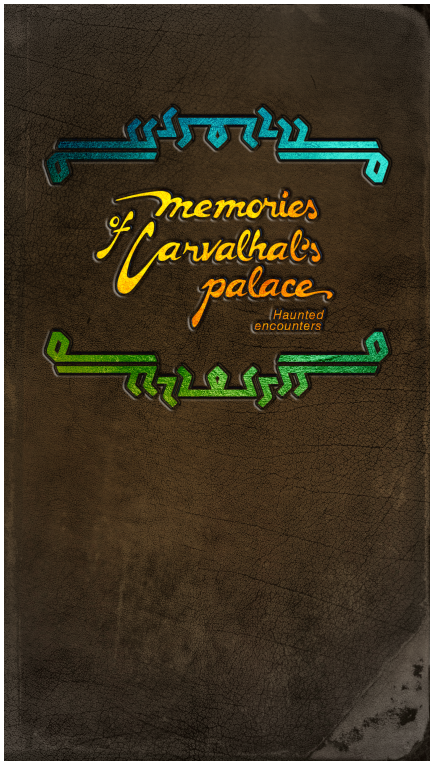
Click on the Next button and follow the interactive narrative inspired by the history of the palace and the family that previously lived there.

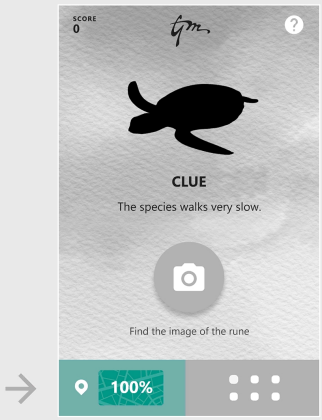


COMPLETE THE TIMELINE

Complete each point of the timeline to solve the mystery and discover the story behind the museum.

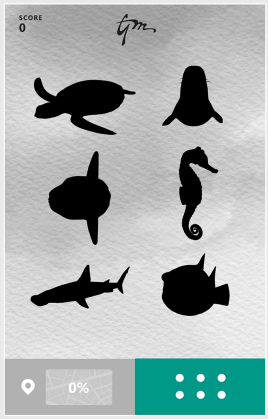
Appendix 25. Tutorial of the *Haunted Encounters* experience





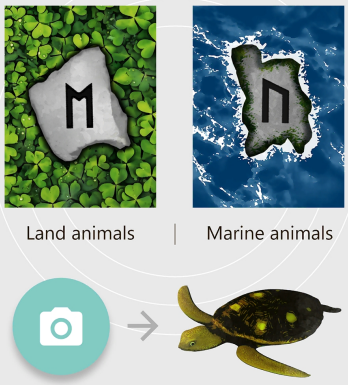
OBJECTIVE

Complete the map to solve the mystery.
The animals in the museum will help you.



HOW?

Find out which animals match the shadows and get pieces to complete the map.



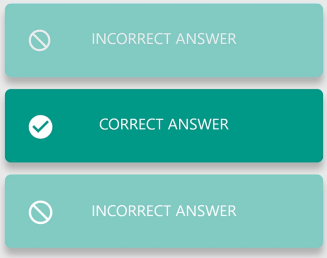
RUNES *

Click on the camera icon when you have found the species' rune.

(*) Of nordic origin were used as charms due to its deeper meanings, rune can mean "secret" or "something hidden".

3D IMAGE

Interact with the animal through Augmented Reality.

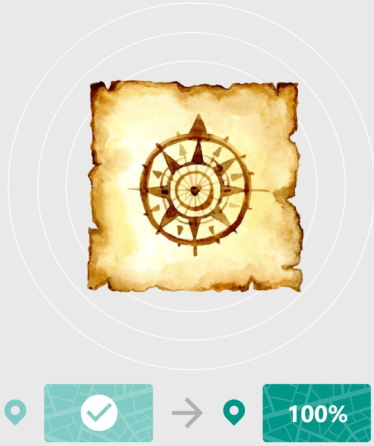


QUESTION

Answer a question about the animal.

INFORMATION

Know the animals through scientific facts.



PIECES OF THE MAP

Get 6 pieces to complete the map and to unlock the mystery.

Appendix 26. Consents delivered to the teenage participants to take part in the evaluation of MoCP dual experience

Informação ao Participante de Investigação e Consentimento Informado

Título do Estudo: Teste de uma aplicação digital no Museu de História Natural do Funchal

Investigador Principal: Vanessa Cesário, Doutoranda em Medias Digitais
Madeira Interactive Technologies Institute & Faculdade de Engenharia da Universidade do Porto
+351 967 972 390, vanessa.cesario@m-iti.org

Objetivo do Estudo
O objetivo principal desta investigação é avaliar como é que os jovens se sentem ao realizar uma visita interativa, no Museu de História Natural do Funchal (O Aquário), com recurso a um jogo de realidade aumentada – *Memories of Carvalhal's Palace: Haunted Encounters*.

Procedimento
A visita ao Museu de História Natural do Funchal está programada para dia [XX/XX/XX] pelas [XXhXX], e terá a duração máxima de duas horas. Toda a deslocação entre a Escola Secundária [XX] e o Museu será coordenada pela Prof. [XX].

A visita terá o seguinte procedimento:
- Os alunos serão recebidos no museu e dirigidos para a Sala A onde serão divididos em grupos de 2.
- Será fornecido 1 *smartphone* por cada duas pessoas e acesso à internet para testarem a aplicação.
- Os grupos de dois sairão da Sala A para as salas comuns do museu de forma a testarem a aplicação.
- Cada dois grupos de dois sairão da Sala A com um espaço de 5 minutos em relação aos outros, os restantes ficarão na sala aguardando a sua vez.
- Os utilizadores terão no máximo 30 minutos para testarem as aplicações nas salas comuns e alcançarem o último ponto do jogo que é uma localização específica dentro do museu.
- Após o término do jogo, os grupos serão conduzidos para a Sala B.
- Na Sala B, um investigador fará algumas questões gerais aos grupos acerca do que estes acharam da experiência.
- De seguida, o investigador distribuirá questionários relativos à avaliação da interação com a aplicação, que os alunos serão solicitados a preencher.

Critérios de Inclusão
Será considerado elegível para participar neste estudo se for estudante e possuir entre os 15 e os 20 anos de idade.

Custos
A participação nesta investigação não tem qualquer custo para o participante.

Confidencialidade
A confidencialidade dos dados será mantida das seguintes formas: os dados dos participantes serão guardados separadamente; esta declaração de consentimento estará mantida nas instalações do *Madeira Interactive Technologies Institute* e não será divulgada a terceiros. Ao aceitar participar neste estudo, o participante também aceita que a sua informação recolhida

durante a experiência seja objeto de análise e de futuras publicações científicas. Para proteger a sua privacidade, ser-lhe-á atribuído um código e toda a informação recolhida sobre si será gravada através deste código, não contendo nunca o seu nome.

Direitos
A participação do estudante é voluntária. O estudante é livre de interromper a sua participação em qualquer momento. A recusa em participar ou interrupção da participação não resultará em qualquer penalização, ou perda de eventuais benefícios ou direitos. O investigador principal poderá decidir, de forma fundamentada, interromper algumas participações neste estudo. Caso se verifique esta situação, esta não resultará em qualquer penalização, ou perda de eventuais benefícios ou direitos.

Autorização
Assinale com um **X** qual das afirmações autoriza:
Entendo que os investigadores possam querer usar fotografias e áudio por razões ilustrativas nas apresentações e publicações deste trabalho, para fins científicos ou educativos.
[ ] *Eu dou autorização para fazê-lo, desde que o* ***rosto do meu educando não*** *apareça.*
[ ] *Eu dou autorização para fazê-lo, desde que o* ***rosto do meu educando apareça****.*

Esclarecimento de Dúvidas & Contactos
Se você tem dúvidas sobre este estudo, desejar obter mais informações, ou desejar interromper a sua participação no estudo, entre em contacto com o Investigador Principal em pessoa, por telefone ou e-mail. A informação de contacto está disponível no início da primeira página deste documento.

Menores
Os menores (indivíduos com idade inferior a 18 anos) não podem legalmente dar o consentimento para participar em estudos de investigação. O consentimento deve ser dado pelo seu encarregado de educação.
Ao assinar este documento, você confirma que leu a informação acima descrita sobre este estudo, e que todas as suas perguntas foram respondidas. Você poderá também fazer perguntas adicionais a qualquer momento durante o estudo, e mesmo após este ter terminado.
Ao assinar este documento, você concorda que o seu educando participe neste estudo de investigação.

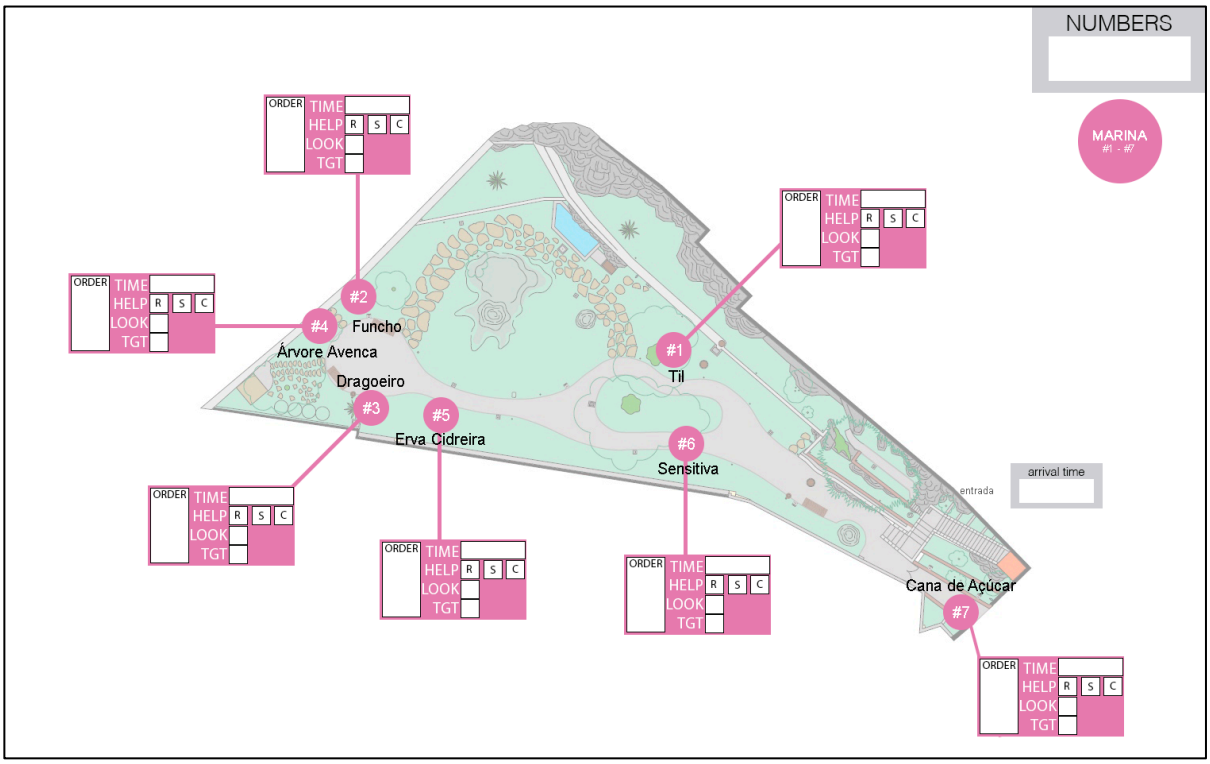
_____ _____
ASSINATURA DO ENCARREGADO DE EDUCAÇÃO DATA

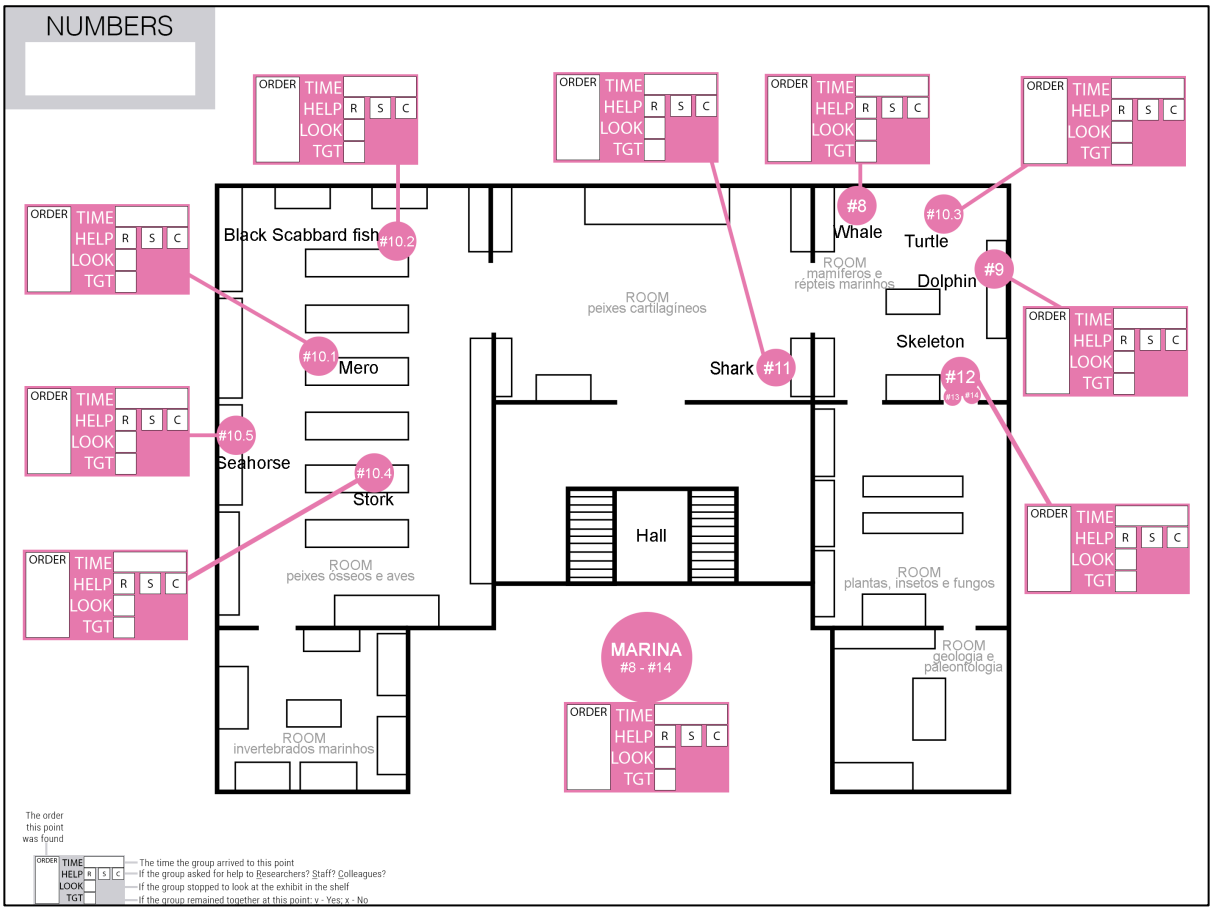
_____
NOME DO ALUNO

Investigador que obtém o consentimento
Como membro da equipa de investigação, confirmo que expliquei ao participante acima referido a natureza e finalidade deste estudo de investigação. Estou disponível para esclarecer quaisquer dúvidas que possam surgir ao longo do estudo.

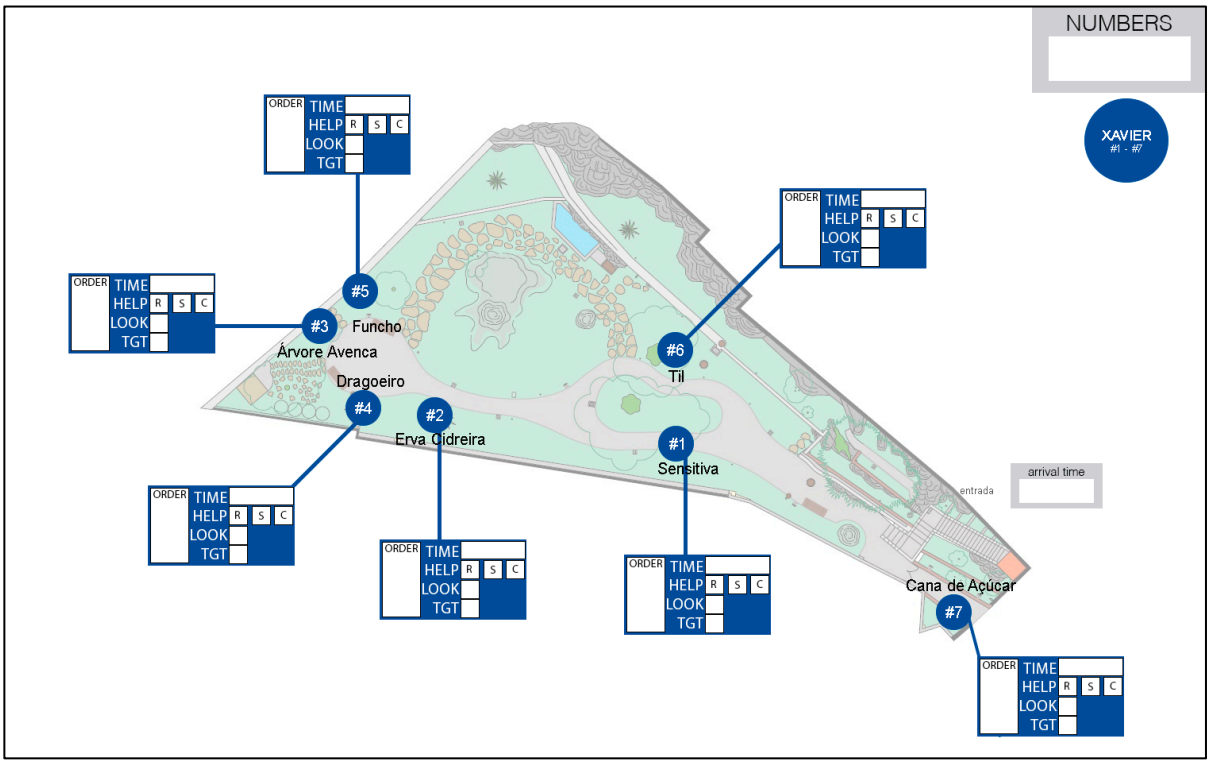
_____ 11-02-2019
ASSINATURA DO INVESTIGADOR DATA

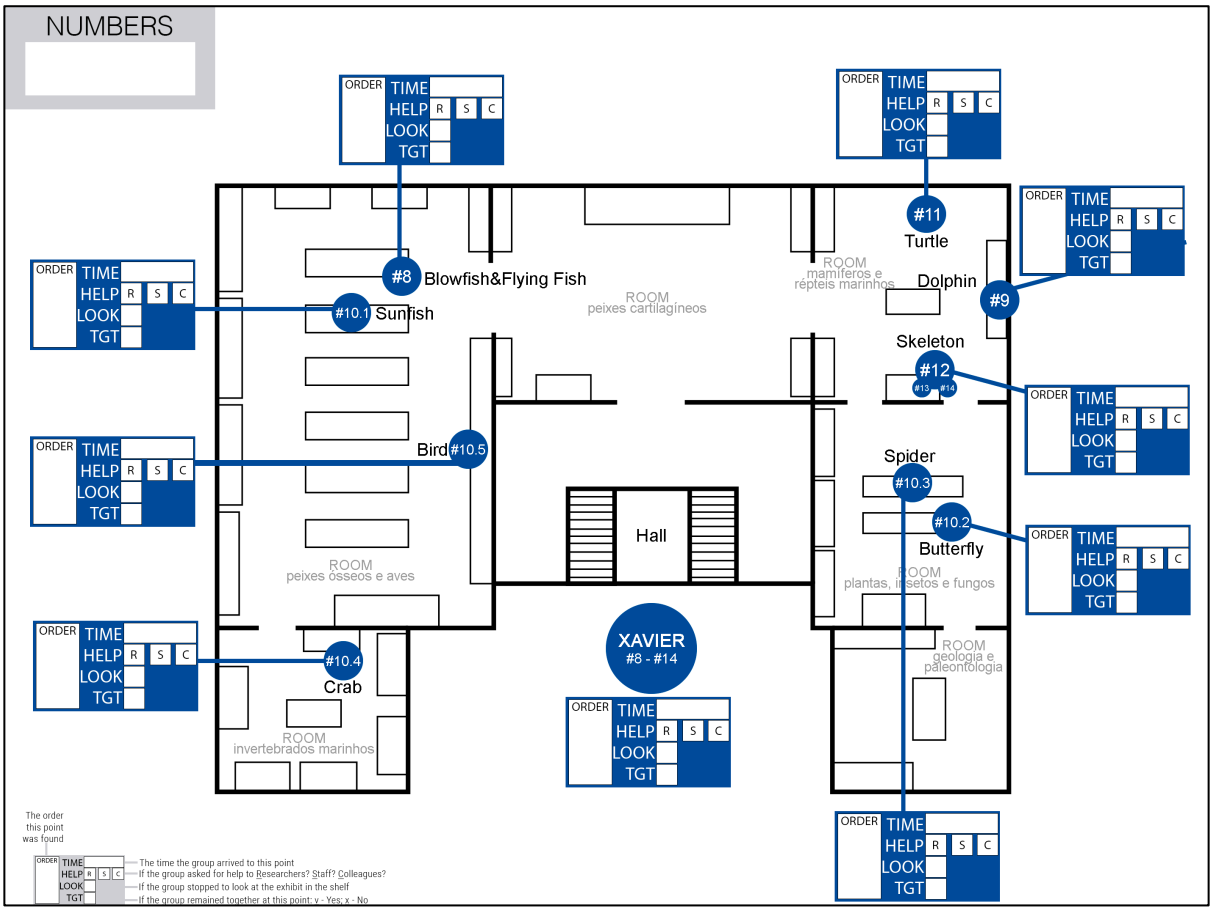
Appendix 27. *Turning Point* observation sheet: version Marina



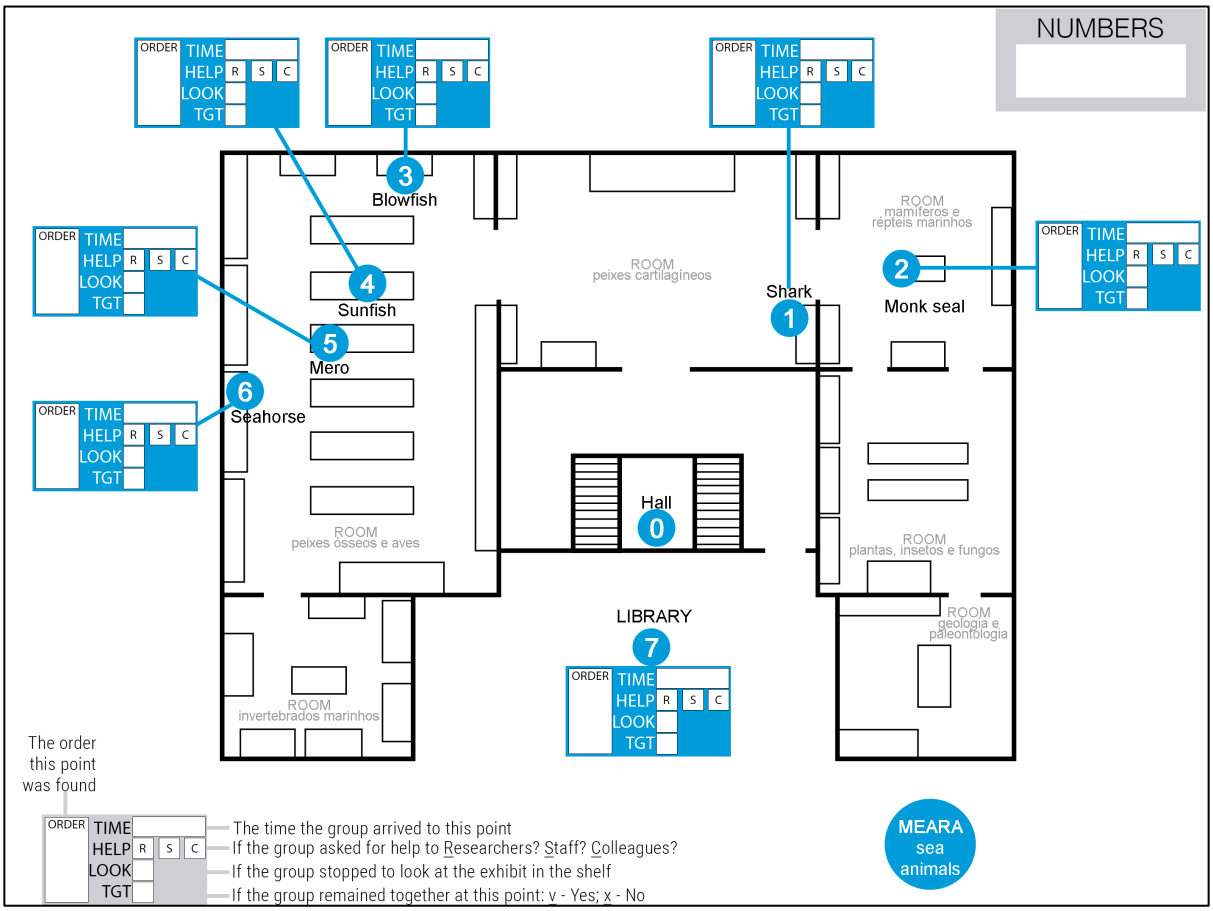


Appendix 28. *Turning Point* observation sheet: version Xavier

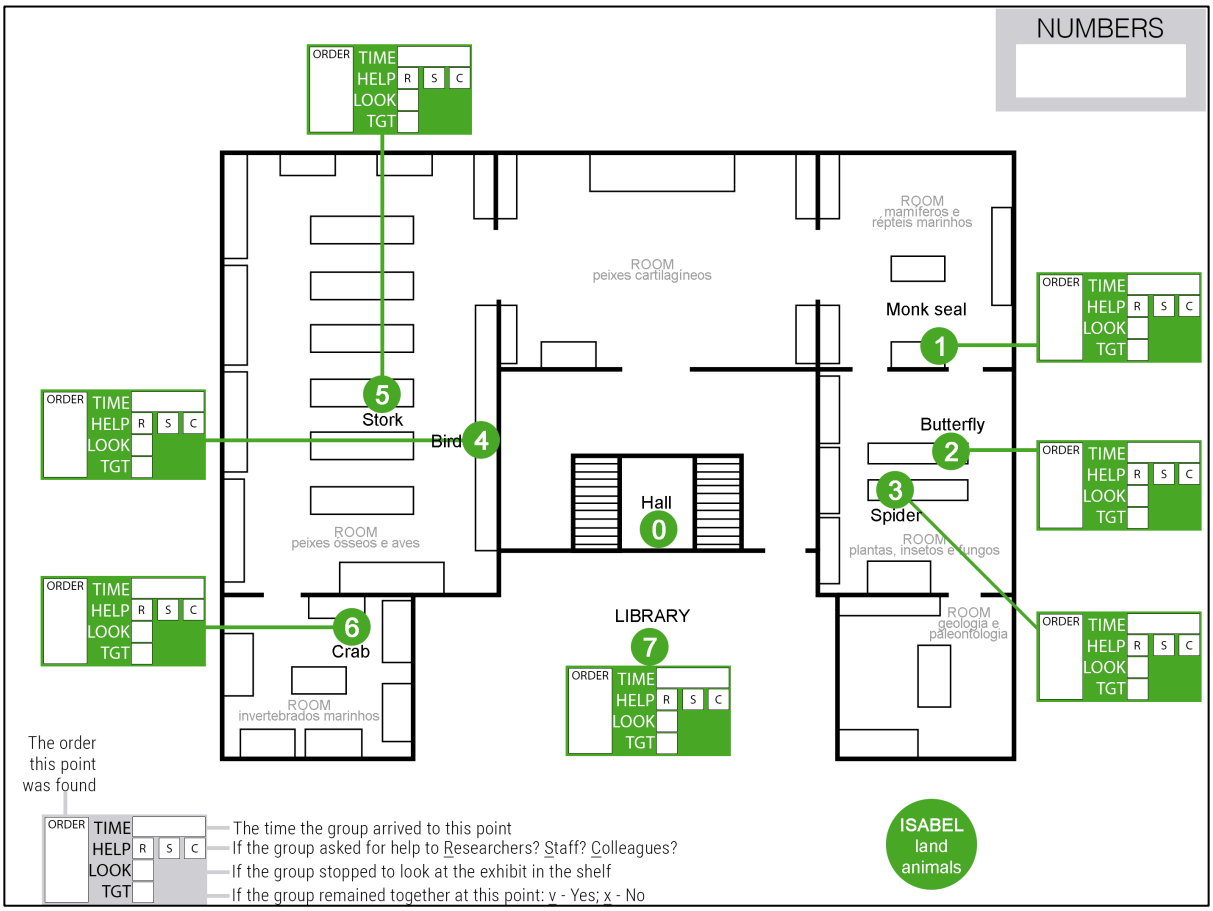




Appendix 29. *Haunted Encounters* observation sheet: version Meara



Appendix 30. *Haunted Encounters* observation sheet: version Isabel



Appendix 31. Game Experience Questionnaire delivered to teenagers

Para cada item da escala seguinte, por favor indica com um **círculo** como te sentiste depois de terminar o jogo.

1. Senti-me renovado.

nada	ligeiramente	moderadamente	razoavelmente	extremamente
0	**1**	**2**	**3**	**4**

2. Senti-me mal.

nada	ligeiramente	moderadamente	razoavelmente	extremamente
0	**1**	**2**	**3**	**4**

3. Achei difícil voltar à realidade.

nada	ligeiramente	moderadamente	razoavelmente	extremamente
0	**1**	**2**	**3**	**4**

4. Senti-me culpado.

nada	ligeiramente	moderadamente	razoavelmente	extremamente
0	**1**	**2**	**3**	**4**

5. Parecia uma vitória.

nada	ligeiramente	moderadamente	razoavelmente	extremamente
0	**1**	**2**	**3**	**4**

6. Achei um desperdício de tempo.

nada	ligeiramente	moderadamente	razoavelmente	extremamente
0	**1**	**2**	**3**	**4**

7. Senti-me com energia.

nada	ligeiramente	moderadamente	razoavelmente	extremamente
0	**1**	**2**	**3**	**4**

8. Senti-me satisfeito.

nada	ligeiramente	moderadamente	razoavelmente	extremamente
0	**1**	**2**	**3**	**4**

9. Senti-me desorientado.

nada	ligeiramente	moderadamente	razoavelmente	extremamente
0	**1**	**2**	**3**	**4**

10. Senti-me exausto.

nada	ligeiramente	moderadamente	razoavelmente	extremamente
0	**1**	**2**	**3**	**4**

11. Senti que poderia ter feito coisas mais úteis.

nada	ligeiramente	moderadamente	razoavelmente	extremamente
0	**1**	**2**	**3**	**4**

12. Senti-me poderoso.

nada	ligeiramente	moderadamente	razoavelmente	extremamente
0	**1**	**2**	**3**	**4**

13. Senti-me cansado.

nada	ligeiramente	moderadamente	razoavelmente	extremamente
0	**1**	**2**	**3**	**4**

14. Senti-me arrependido.

nada	ligeiramente	moderadamente	razoavelmente	extremamente
0	**1**	**2**	**3**	**4**

15. Senti-me envergonhado.

nada	ligeiramente	moderadamente	razoavelmente	extremamente
0	**1**	**2**	**3**	**4**

16. Senti-me orgulhoso.

nada	ligeiramente	moderadamente	razoavelmente	extremamente
0	**1**	**2**	**3**	**4**

17. Tive a sensação de que tinha voltado de uma viagem.

nada	ligeiramente	moderadamente	razoavelmente	extremamente
0	**1**	**2**	**3**	**4**