Sheffield Hallam University

Teenage Visitor Experience: Classification of Behavioral Dynamics in Museums

CESARIO, Vanessa, PETRELLI, Daniela <http://orcid.org/0000-0003-4103-3565> and NISI, Valentina

Teenage Visitor Experience: Classification of Behavioral Dynamics in Museums

Vanessa Cesário
ITI/LARSyS, FEUP
Funchal, Portugal
vanessa.cesario@m-iti.org

Daniela Petrelli
Art & Design Research Centre,
Sheffield Hallam University, UK
d.petrelli@shu.ac.uk

Valentina Nisi
ITI/LARSyS, UMa
Funchal, Portugal
valentina.nisi@m-iti.org

ABSTRACT

Teenagers' engagement in museums is much talked about but little research has been done to understand their behavior and inform design. Findings from co-design sessions with teenagers suggested they value games and stories when thinking about enjoyable museum tours. Informed by these findings and working with a natural history museum, we designed: a story-based tour (*Turning Point*) and a game-based tour (*Haunted Encounters*), informed by similar content. The two strategies were evaluated with 78 teenagers (15-19 years old) visiting the museum as part of an educational school trip. We assessed teenagers' personality in class; qualitative and quantitative data on their engagement, experience, and usability of the apps were collected at the museum. The triangulation of quantitative and qualitative data show personality traits mapping into different behaviors. We offer implications for the design of museum apps targeted to teenagers, a group known as difficult to reach.

Author Keywords

Museums; mobile experience; teenagers; visitor experience; storytelling; game; co-design.

CSS Concepts

• **Human-centered computing~Human computer interaction (HCI)**; *Empirical studies in HCI*

INTRODUCTION

Locative media and the use of mobile devices to enhance and enrich museum visits have been extensively studied [5,12,26,30,36,38,39,52]. On the other hand, museums are promising settings for gamification [47]: mystery and treasure-hunting [11,21] as well as problem solving tasks [4,18,44,47,56] have the potential to engage and entertain. In addition, stories and games can scaffold informal learning in museums by building upon the playful aspects of the visit [20,35,43,59]. The combination of mobile devices, locative media, games and storytelling offer museums an opportunity to widen their offer: visitors have

different motivations and social context that impacts on their behavior and challenge the "one size fits all" approach to museum interpretation [24]. Museums best practices suggests to segment audiences in groups with respect to their motivations, social group, and expectations [42]. Indeed, most museums already offer different educational programs for different ages (junior school vs. high school) or activities for families or collection handling for adults. 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 [15]. For the challenges they pose, teenagers, are often excluded from a museum's curatorial strategies [57]. It is a vicious circle: the design of interpretive experiences is not sensitive to this group's specific interests and needs thus limiting the museum's potential to create interpretative experiences that have real pedagogical relevance [57].

This research was conducted in collaboration with the Natural History Museum of Funchal (NHMF), Madeira Island, Portugal. Once the historical home of the Count of Carvalhal, NHMF is a very traditional museum with rooms full of display cases and taxidermized animals described by labels and panels. Our work is an attempt to address the museum's concerns on making the museum interesting for teenagers aged 15-19 that already visit the museum as part of their school trips. The museum further constrained our design intervention to adding a few small labels, asking us not to modify the museum layout. The overall project was articulated in: (i) a set of generative workshops in which 46 groups of teenagers (155 participants) created concepts for interactive experiences on mobile devices for the NHMF; (ii) the analysis of the concepts inspired the design of two different experiences, one centered on gaming, one on storytelling; and (iii) the evaluation of the apps with respect to the personality of the visitors, classes of teenagers in an educational school trip (78 participants). This paper focuses on this last phase, the evaluation: we aimed to understand how teenagers responded to different engagement strategies (games vs. storytelling) and to cross check their response with personal attitudes. For this purpose, prior to their visit, a personality test was administered in class to gather data on their overall attitude. During the visit, conducted in pair, we recorded their conversation to gather details on their concerns and feelings about the museum and the mobile app itself. We then cross the results of the personality tests with the analysis of their behavior in the museum while

experiencing the two different strategies to determine if there is any correlation. Our findings show a polarization of attitude towards one specific interaction's strategy that have implications for the design of museum apps.

In the first part of this contribution, we discuss related work on playful interaction in museums. We then summarize the creative workshops with teenagers and the rationale for the two apps. The paper then reports the evaluation study, highlighting different visiting behaviors and personal attitudes. Reflecting on the results, we propose implications for the design of interactive museum apps targeted to teenagers.

PLAYFUL INTERACTION IN MUSEUMS[1]

Storytelling and game-based approaches fits museums goals as they promote joyful and exciting experiences [23,31,50]. Ludologists and narratologists tried to define the driving strategies and building blocks in digital games and interactive narratives [2, 3, 7,31,32,35,40,48,58]. We share Aarseth's view [1] that as technologies evolve and get mass adopted, the differences between digital games and interactive stories are harder to draw. Instead of focusing on the differences, these two modes of entertainment should work together, borrowing from each other's strategies in order to deliver engaging and compelling aesthetics experiences. Game experience can use narrative to drive players engagement and motivation, and, vice versa, interactive narratives can use game elements to create agency and involve the reader in co-creating the experience through choices and active engagement. Aware of this debate, we did not split game and story approaches down one clear line, as we acknowledge the nuances. We designed our museum apps to incorporate elements of both to make the outcome more effective in capturing teens preferences, but leaning towards one or the other in order to create two strategies: the game-based strategy leans towards challenges based on quizzes and collection of items; the story-based strategy privileges plot development, characters dialogues and transformations. In this way, our study aims at capturing variations in teens preferences while better understanding how different teenagers' personalities react to different engagement strategies.

Game-based approaches

Museums are hubs where children can be entertained while learning by solving challenges [25]. Game-based museum experiences for different media and visitor types have been designed and extensively studied. The mobile game at the Maryland Science Centre increased the exhibition's engagement of pre-teens participants (8-12 years old) of two-thirds, while 88% reported learning more about the exhibit than without it [54]. While the target audience is slightly younger than ours, the benefits of the mobile app in

engaging visitors with the museum are evident. *Ghosts of a Chance* [6] uses clues and puzzles to encourage visitors (adults and teenagers) to think about art in a fun and social way. The success of the apps highlights the opportunity for museum curators and experience designers, to embrace fun and social activities in parallel with the learning goals. The study of the game *QuesTinSitu* [40] shows how small groups of visitors (14-16 years old) enjoyed the museum gaming activity more than larger groups, being more engaged and concentrated. We took this finding at heart and designed our experiences for pairs, so to stimulate dialogue, sharing and engagement. Moreover, Coenen et al. [19] warns on the dangers of overwhelming the visitors (18-30 years old) when expanding the experience across large areas without guidance or constrains. In short, when designing game-based approaches for museums, the integration of treasure-hunt elements positively engages visitors [54], allowing them to explore the space freely, according to their own interests and agenda [54], but attention must be paid not to overwhelm them. The use of clues can be a successful strategy in orienting the players [19] and the integration of competition elements such as quizzes and puzzles to solve [53,54] can enhance the visit by adding fun. Collection of virtual items is a positive strategy to engage teens as it provides them with a mission. An understanding of different audiences and their motivations for collecting could inform winning strategies of encouraging visitors to engage with museums [44]. Moreover, teenagers enjoy connecting to the exhibits through their past experiences/memories [6,53].

Story-based approaches

Narratives approaches generate personal connections between visitors and content, hence they can enhance museum experiences [7,33]. Interactive storytelling has become a popular way to guide museum visitors, giving them a thread to follow in taking in the exhibits, helping with orientation and preventing them in getting lost [49]. Studying story-driven treasure-hunts in museums, Radeta et al. [50] highlight how ubiquitous stories and games positively influence the level of excitement and engagement with the museum. Young teens (10-12 years old) were observed running through the corridors, excited by the activities, while paying attention to the feedback on the smartphone as well as the artefacts surrounding them [50]. The study of the *Mystery in the Museum* story-driven experience [11], designed for and evaluated with 15-16 years old teens, warns us against the dangers of designing for the success of the mobile app rather than the museum exhibition. Visitors interacted with the exhibits only marginally, to solve the mystery, rather than because they were interested in the museum offer. Aware of these previous studies, we designed a story that touched on the museum and its history, the exhibits and their scientific aspects, in a way such as to unravel the plot requires learning about the museum and its exhibits.

---

[1] HCI research in museums is vast (see [29] for an up-to-dated review) therefore we limit our discussion to previous work that addresses storytelling, games, or teenagers.

Museums are intended to draw people together to discover and learn new things about the world. Curiosity is a core motivation to engage with the exhibits, drawing people in, leading them to ask questions. Through art and storytelling, visitors can immediately engage in learning, without needing any prior scientific knowledge. Beyond the scope and space for this article, an extensive review of interactive storytelling and museums can be found at [58].

Technology and interaction in museums
Technology can create personal connections between the teenage users and the information content, inspiring them to take a closer look. However, care should be taken on the complexity of the tasks [11] or the usability of the application [43] which could absorb the visitors' attention to the detriment of the exhibition. Another problem arises when visitors, prompted by the app to search the right exhibit, run through the halls without paying much attention to the museum itself being focused on the screen and failing to observe the physical exhibit [43]. Competition in a digital museum tour can be a winning strategy when supporting positive interactions, sharing of knowledge and collaborations, letting visitors explore the museum carefully, learn about the exhibits, and progress through the experience without disrupting others' visit [53,54]. However, competition can promote unfair and careless behaviors, such as noise, running to get there first, and missing to appreciate the exhibits [43,50]. In summary, findings distilled from the related work discussed above, inspired and encouraged us to design for interactions that promote positive behaviors. We kept this in mind throughout our design process and designed for multiple experiences for the same museum offering visitors with different information and journeys, delivered by two distinct experience strategies.

RESEARCH QUESTION AND CONTRIBUTION
Falk argues [24] that personal motivations and attitudes affect the individual behavior and thus the visiting experience cannot be ascribed exclusively to the museum itself. In other words, different people respond in different ways to what the museum offers. Therefore, museums should implement different strategies to better engage different types of visitors. Which engagement strategy is most suitable to which type of visitors is the focus of this study. To ascertain how personal attitudes and engagement strategies combine or clash, we collected personality tests, in advance of the visit. Later, in the museum pairs of teenagers engaged with one of the two strategies (game-based or story-based) to explore the museum exhibits. With such motivation and problem statement, we addressed these research questions:

1) Do different interactive strategies (game-based and story-based) induce different behaviors in teenagers visiting a museum?

2) To what extent would different personality traits map the behavior of teenagers interacting with different strategies?

3) What are the implications for the design of story-based and game-based strategies in museums?

This research contributes to a better understanding of the museum visiting behavior of 15-19 years old in order to inform the design of mobile museum apps.

CO-DESIGNING WITH TEENAGERS
To better understand teenagers' preference when visiting museums, we adopted a user-driven innovation framework [10] along with a cooperative inquiry approach that positions participants as "design partners" [22]. This combination resulted in a co-design framework [17] that involves teenage users in the ideation of mobile experiences for their local museum, bearing in mind the use of mobiles. In 13 workshops of 90 minutes, we harnessed teenagers' experiences and ideas as valuable sources of information and inspiration to understand how museum visits could be enhanced from the teenagers' perspective. Key for design was to better understand which features would entice teenagers to take an interactive mobile tour. We involved 46 groups of teenagers (155 participants) to generate concepts. Each group was given two working sheets:

– A *concept sheet,* to capture the overall visiting experience concept. The following questions guided participants: i) Narrative: what is the narrative underlying the experience? ii) Species/Artefacts: how do visitors interact with the museum's artefacts? iii) Mechanics/Tutorial: which steps do users have to take to complete the experience?
– An *interface design sheet,* where students had to draw detailed wireframes screenshots of the interface for the concept they just generated.

During the co-design process, a researcher observed the group dynamics and made sure participants were thinking about experiences that they themselves would enjoy and be engaged with. By working in groups, teenagers played an active role in the creation and development of ideas acting as informants and as a source of innovation. Through a cooperative inquiry approach [22], the researcher had initially a side role, that of guiding the participants' voices through the predetermined schedule for the session; after the workshop, the researcher analyzed the concepts generated by the teenagers.

The compiled sheets with participants' ideas and preferences were analyzed; we were looking for trends, and concept generation, according to Hakkila et al.'s methods [28]. Participants' writing was transcribed while graphic elements were coded. Text and graphics were brought together in the same data set to identify the categories and themes emerging from what the teenagers considered to be enjoyable, interactive apps for museums (details in [13]). The results of the co-design sessions (see [13,14,16]) suggested that teenagers particularly appreciate mobile experiences that include novel technologies, in particular Augmented Reality (AR) and Virtual Reality (VR); they are

also keen to share their experiences via social media; they favor options for different tours to engage with different content; and suggest a mix of stories and games (they proposed games with treasure-hunts, competition, timeout and collection strategies; and stories that give the opportunity to become protagonists of the experience, engage directly with the exhibits and connect to it emotionally when possible). All these elements that emerged as important in the creative phase were taken into account in the design phase discussed next.

MEMORIES OF CARVALHAL'S PALACE

The NHMF was instrumental throughout the project. The museum provided the challenge to engage teenagers; the setting and inspiration for the creative workshops; support in the development of the *Memories of Carvalhal's Palace* (MoCP) and as venue for the final study. A production team from the Interactive Technologies Institute, based in the island of Madeira, developed the apps; content for the apps were provided by the museum. Several meetings with the director were carried out to understand the museum's message and goals in engaging their teenager audience. The NHMF's mission is to raise awareness of the preservation of the natural heritage of the island of Madeira, especially its endangered species. The museum also wanted to increase interest in their scientific library, the garden of aromatic plants, and the history of the museum as a building. To inform design, the production team attended several museum tours to better understand the building and the main species on display. When familiar with the museum, its aims and goals, the production team selected the rooms and species for the apps; they also researched and assembled information for the app. The museum director and the staff then assessed the apps to verify and approve the content displayed as well as to test their usability.

Based on the same background story, museum premises and exhibits, and informed by the co-design with teenagers, the MoCP implements two different interaction strategies to be compared and evaluated in the study. Rather than being radically different, the two interaction strategies use both game and storytelling techniques but at different degrees: one is game-based, centered on a game with storytelling as a background – *Haunted Encounters* (HE) – the other is story-based, centered on storytelling with elements of game mechanics – *Turning Point* (TP) (see videos figures). Both approaches rely on finding AR markers that indicate the presence of digital content. AR was chosen as main interaction modality to trigger information about the main species and aromatic plants on display, and the historical significance of the museum building, which was once the residency of a noble Madeiran family. The fictional plot of the MoCP revolves around the Carvalhal's family that owned the palace that today hosts the museum. The young heir, Xavier, falls in love with a young lady, Marina, but she mysteriously disappears leaving him waiting at the altar. Xavier cannot come to terms with the grief caused by this loss and lingers in the museum as a restless ghost. After

listening to this introductory story, the audience is prompted to help the characters to find the truth about several mysteries hidden in the museum by interacting with the museum's taxidermied species. The two apps lay on the canvas of this fictional plot. HE implements a ludic strategy; the focus is on the rules by which the player actively collects points to achieve goals. TP implements a narrative strategy; the focus is on the storytelling and the visitor collects fragments of the story while visiting.

Game-based: Haunted Encounters (HE)

HE is a location-based game which takes the visitor throughout 6 places in the museum by helping a pleading character (Isabel or Meara – mothers of Xavier and Marina respectively) to uncover mysterious events in the museum.
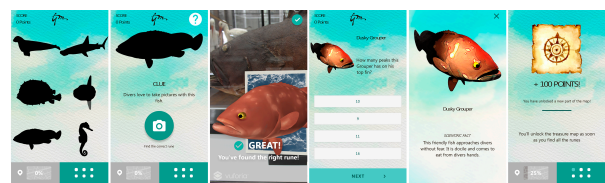

Figure 1. Screenshots of Haunted Encounters (left to right): 1) the shadows' interface; 2) the clue for finding the Dusky Grouper; 3) the 3D model of the Dusky Grouper displayed as Augmented Reality; 4) the question regarding a selected species; 5) a species' scientific fact; 6) the points earned by answering the question.

Through a game of shadows, the visitor is challenged to find and interact with 3D models of the animals on display, answer quizzes about the exhibits (one should look at the displayed exhibits in order to answer the quizzes), and collect fragments of a treasure map in order to unlock the mysteries in the palace (Fig. 1). While following the trail and answering the quizzes, visitors collect points for each correct answer. Visitors can also 'ask the app for help' to find the location of the species, but in return they will lose points. After finding 6 species, the visitor is guided to the hidden scientific library of the museum and invited to a physical treasure-hunt which unlocks a digital ghost-detector. If the player has been helping Meara, Xavier's ghost of the groom left at the altar will appear, and the visitor will understand that something terrible must have happened for him to have become a grieving ghost. If the player was helping Isabel, then the ghost encountered will be the one of herself. Evil Isabel took an active part in destroying Xavier and Marina's wedding, and she will continue to be evil, in this case by taking all of the points the player had collected.

Story-based: Turning Point (TP)

In TP, the audience is invited to explore 13 points across the museum interior and exterior premises to find and unlock story's fragments. The visitor chooses to follow one of the character's drama (Marina or Xavier), and collect sequential fragments of their story. The app will guide the visitor to pay attention to various plants and animals exhibits, where they can find AR markers, each of which

unlocks a new story fragment. When encountering a fragment, users press on the 'next' button (Fig. 2 – right side), to play the story audio-visuals. By clicking on the button multiple times, users can skip the narration, and quickly reach the end of the story fragment.
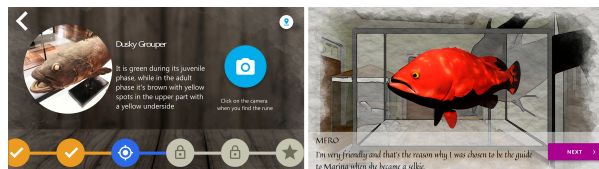
Figure 2. Screenshots of Turning Point. Left) Info given to the user to help them find Dusky Grouper in the museum, along with some of its scientific info; Right) Dusky Grouper presenting itself and progressing the story plot.

The story goes that Lord Xavier is tormented by his insecurity regarding Marina corresponding his love. She seems evasive every time they talk about their future together. There seems to be uncertainty regarding their wedding plans. Marina instead is led to believe that her mother's disappearance is connected to Xavier, and that he is hiding something from her. At the same time, both characters are united in their fight against the monk seal hunting practice. Several species in the museum display cases are transformed into living characters within the story. They provide the audience with hints on the mysteries behind the couple and their hidden secrets, while introducing themselves through scientific curiosities. In the last fragment of the story (common for both characters), Xavier and Marina finally meet again in the museum, realize their mistakes, and promise eternal love to each other. In the background, the news of the historical approval for a law protecting monk seal species make the front covers of the local newspapers (real fact).

The two apps, based on the same exhibits and loose story world, implement two different strategies and game/story mechanisms, derived from the teens co-design workshops. Given that personal attitudes and motivations are key to museum appreciation [24], the question was then which app would be more appealing to which type of visitor. A study was then designed to understand how teenagers engage with such strategies and mechanics and if this correlates with their personality traits.

METHODOLOGY
The study was conducted in the NHMF using a between-subjects experimental design: to better understand how the two strategies affect the teens' behaviors, participants visited in pairs and were assigned one of the two experience strategies while exploring the museum. Testing the apps with groups of two people was inspired by [40,55] that found teens enjoy and focused more on the activity when in smaller rather than bigger groups. Overall 78 teenagers (46 females, 32 males) between 15-19 years old (average age of 16.62) volunteered in the study as part of a school visit to the museum. Teachers were interested in the students trying

new modes of visiting museums, and they took part on a voluntary basis. Consent to take part in the study and being recorded was collected from all the participants. Prior to the museum visit, in class, the teenagers took a personality test, to assess their general attitudes. The study at the museum lasted 2-hour for each class of 15/25 students and, for that time, the museum was close to the public and dedicated to the study. When a class arrived, students paired with a partner of their choosing; each pair received a Samsung smartphone with one of the 2 apps running, and a timeslot assigned to them to start their tour to avoid pairs with the same app crossing paths at the same time. In this way pairs were never at the same species at the same time. Audio was recorded through the smartphone throughout the visit to capture the conversation and visiting behavior. Within the museum, the pairs were free to engage with the app and each other in any way they wanted. Researchers, at a distance, observed their behavior and took notes. After the visit, the pairs were interviewed together and, individually, filled in a questionnaire about their engagement with the exhibition, the usability of the mobile app, and their overall experience. We chose to take all this data at the same time in order to have both qualitative and quantitative data on the behavior of each teen with one of the strategies. 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. Overall 46 teenagers (23 pairs) used the game-based HE, and 32 (16 pairs) used the story-based TP. The teenagers who took part in this study did not participate in the creative co-design sessions, as these sessions were conducted in 2017, the design and development occurred in 2018, and the testing was carried out in 2019.

Measures
In this section, we describe the measures applied: the personality test before the visit, the post-visit interview and post-visit questionnaires. In the next section, we discuss the analysis of the data.

While in class, before the visit, students took a *personality test*, a consolidated tool to measure personality with respect to 5 factors [27]:

1) Openness to experience grades people as more imaginative/creative or down-to-earth/conventional;

2) Conscientiousness, a prudent or impulsive person;

3) Extroversion, whether a person is extrovert or introvert;

4) Agreeableness measure the person's attitude toward cooperation and social harmony, it grades them as friendly and cooperative vs. suspicious and aggressive;

5) Neuroticism, people with high neuroticism score are more sensitive and nervous than ones with low score.

Each factor above is measured via ten sub-factor questions. Information on the full study was given and written consent from parents or guardians was collected at this time.

Upon completion of the visit, participants were *interviewed* as a pair to gather qualitative data, regarding their general experience of touring the museum with the app; what they liked and disliked the most; and suggestions for improvements. The interview was audio recorded and then transcribed for the analysis.

For both apps, a *questionnaire* was filled in individually and was composed of three parts:

1) the Museum Experience Scale (MES) [45] measures the visitor's overall experience with the exhibition and the exhibits, specifically: engagement with the display; learning outcome; meaningful interaction with the exhibition and/or other visitors, and the emotional connection;

2) the Multimedia Guide Scale (MGS) [45] measures usefulness and usability of museum guides, specifically: its general usability; learnability and control, and the quality of interaction; and

3) the Game Experience Questionnaire (GEQ) – the post-game module [48] measures reactions after a player has stopped playing. It captures the playing experience based on 4 components with a total of 17 questions: 1) the overall positive experience; and 2) overall negative experience; 3) tiredness; and 4) returning to reality.

By applying both the MES and GEQ, we were able to understand how teens perceived the digital experiences in the museum, while the MGS would report usability problems. These quantitative measures were helpful in complementing the qualitative data collected through in-visit voice recordings and post-visit interviews.

QUALITATIVE ANALYSIS

The recording of the conversation during the visit and the interview were transcribed and paired to analyze the dynamic of each pair. From these recordings, we were able to understand if users stopped and looked at exhibits, if they run from a location to another, or if they were skipping parts of the story. Thematic analysis was used for identifying patterns within data while minimally organizing and describing the data set in detail [9]. By familiarizing ourselves with the data via multiple readings we identified the main topics of their conversations 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. While codes mark interesting phenomena in the data, themes are interpretations of the codes and the data. These themes identify behaviors displayed during the visit. Due to page constraints, the hierarchy of codes (generated in the analysis) from dialogues to behaviors is provided as supplementary material. Below we summarize the process and detail the behaviors. The narratives (voice recordings and interviews) were analyzed as a set to check if similarities emerged across the two strategies. The combined behaviors of each individual in the pair was then looked at to extract *categories* that describe the overall pattern of interaction within the pair and with the app. We begin with the description of the categories in which every pair falls. After understanding these categories (*lovebirds* or *frenemies*), we describe the visiting behavior of the pair in relation to the museum digital experience (*gamers-competitors, gamers-skippers, explorers-achievers, explorers-adventurous, followers* or *uncomfortable*), giving examples of how those apply to the different categories.

Behavior between the teenagers of a pair

Lovebirds. Pairs categorized 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 – working as a pair to accomplish what has been agreed and 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. They 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.

Teenagers' behavior with the mobile strategy and the museum

Gamer

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. Their primary objective is to complete the tour. *Gamers* are *Competitors* when interacting with the game and *Skippers* with the story.

Gamers-Competitors (only present in the game-based HE) approach the digital tour with a competitive attitude. 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 and are excited about finding exhibits, they are focused on achievement and progression, and only really 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. They use expressions such as "*100 points! Oh yeah!*" when correctly answered a question; "*Are you dumb?? We had just lost 45 points!*" blaming the partner which wrongly responded to a question; "*Now lock the door for no one to follow us!*" to make sure they will win. *Competitors* often fall into the *frenemies* category. Most of the times, one person 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 (only present in the story-based 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. 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.

Explorer

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 at, 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. 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.

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. *Explorers-Achievers* usually use expressions such as "*If we fail, we fail*" showing little concern in winning or being better than the others; "*Check this with me*" to make sure they are thinking together and choosing the right answer; "*Look at this size! Imagine that we see one of these in the sea*" when amazed by the size of the exhibits encountered.

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. *Explorers-Adventurous* use expressions such as "*Look! This is a goat! Is it real?*" when amazed and curious about exhibits; "*Wasn't this the little one who had been slapped?*" and "*I think we are in the garden of this story*" when relating their experience with the story they are listening to. *Explorer-Adventurous*, fall into both categories of *lovebirds*, and *frenemies*. If *lovebirds*, 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.

Follower

Followers (only present in the story-based HE), are willing to listen and take in the full story as they are intrigued by its plot. 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 and collection, *followers* tend to talk about the species encountered and relate them to their past experiences. They use expressions such as "*I think she is about to transform herself into a mermaid*" for predicting what is going to happen next; "*This was so sad!*" when touched by an event in the story; "*I have a feeling that her boyfriend is innocent*" when making assumption about the end of the story. *Followers* fall more into the *lovebirds* category, than in *frenemies*. 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*).

Uncomfortable

Uncomfortable participants (only present in the game-based 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 fastest 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. *Uncomfortable* visitors can be either *lovebirds* or *frenemies*. 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*).

QUANTITATIVE ANALYSIS

As our goal is to see if a strategy is conductive of a specific behavior, in this section we apply statistical methods to the results of the qualitative analysis, of the personality test and post-questionnaires, to see if there is any statistical significance or trend. We want to verify the correlation between the personality test and the museum visitors' behavior. If such correlation is positive, then we can infer visitor's reactions to a specific engagement strategy.

Statistical tests were then applied to verify if there was any significant correlation between visitors behaviors (as a pair – *Lovebirds/Frenemies* – and with the app – *Gamer/Explorer/Follower/Uncomfortable*) and the data resulting from questionnaires collected before and after the visit: the pre-visit personality test (that assessed *openness*, *conscientiousness*, *extroversion*, *agreeableness*, and *neuroticism*) and the three post-visit questionnaires – Museum Experience Scale, MES (that assessed *engagement*, *knowledge*, *meaningful experience*, *emotional connection*), Multimedia Guide Scale, MGS (that assessed *general usability*, *learning and control* of the app, *quality of interaction* of the app), Game Experience Questionnaire, GEQ (that assessed *positive experience*, *negative experience*, *tiredness*, *returning to reality*). For each of the 16 variables listed above (in italics), we applied the Mann-Whitney Test to find differences in distribution and means between two small samples. The statistical details are included as supplementary material. Here below we summarize the significant results and focus our discussion on how the statistics complements the qualitative findings.

Story-based: Turning Point

Positive experience is significant between *Adventurous* and *Followers,* suggesting that curiosity and the desire to discover are key factors to engage with story driven digital museum tour. Moreover, this finding suggests and confirms that beside *Adventurous* being very curious for details and exploring the museum, they have a more positive experience than *Followers,* who are more concerned with the story and exhibits than the mobile phone. Some personality traits were more relevant for this experience than others: *Adventurous* tend to have a more creative personality while *Followers* tend to be more prudent. *Adventurous* tend to be more cooperative, while *Skippers* tend to be more neurotic. The match personality trait – behavior is consistent with the type of experience: a *Skipper* is impatient and ignores much of the story; *Followers* want to make sure they did not miss anything important; *Adventurous* use the story as a means to explore and go further, they visit the museum in their own way.

Significant correlations were found between the four personality dimensions (*openness, consciousness, agreeableness, neurotics*). *Openness,* measured on a scale from conventional to creative, shows *Adventurous* being more creative than *Skippers* and *Achievers*. This can be explained by *Skippers* and *Achievers* concentrating on winning instead of immersing themselves in the experience, which, on the other hand, is the main focus of the *Adventurous*. *Consciousness* (imprudent, prudent) is significant between *Followers* and *Skippers*: *Followers* are more prudent than *Skippers* because they carefully listen to the whole story instead of skipping fragments to finish faster. *Agreeableness* (aggressive, cooperative) is significant between *Adventurous* and *Skippers,* with the first ones being more cooperative while the seconds display a more aggressive attitude to finish and win. *Skippers* are more sensitive, hence *neurotics* (less/more sensitive) than *Adventurous* and focus on finishing the tour first, while *Adventurous,* which are less *neurotic*, prefer to visit the museum in a relaxed way.

Game-based: Haunted Encounters

Positive experience is significant between *Competitors* and *Achievers. Competitors* had a more positive experience than *Achievers*. In their aim to be successful, these two behaviors are one and the same: competition. However, findings suggest that people competing against others (*Competitors*) are more likely to have a more positive experience than those competing against themselves (*Achievers*). While on one hand, the positive experience indicates success of the apps, some of the *Competitors* behaviors observed in the study lack ethics and attention to basic social norms. In terms of personality traits, *Uncomfortable* tend to be less creative than *Competitors*, as they feel unease in taking things in their own hands and

make choices, while *Competitors* are more prudent than *Uncomfortable,* because they really care about taking the right decisions as they want to be the best. These results can be expected when the major feature of the app asks the visitor to act and take decisions.

Significant correlations were found in two personality dimensions (*openness* and *conscientiousness*), as well as in the dimensions of *"return to reality"*, *"learning and control"* of the app, *"quality of interaction"*, *"tiredness"*, and *"emotional connection"*. *Openness* (conventional, creative) is significant between *Competitors* more creative than *Uncomfortable* (more conventional). *Uncomfortable* are insecure, they are concerned about the others and worried about the technology and the game mechanics. *Consciousness* (imprudent, prudent) is significant between *Competitors* and *Achievers*. *Competitors* tend to be prudent and carefully seek the right answer; while *Achievers* tend to be more impulsive in their progression. *Return to Reality* is significant between *Competitors*, which are very immersed in the game and find it harder to return to reality, more than the *Adventurous*, *Achievers*, and *Uncomfortable*. *Learning and control* of the app is significant between *Achievers* and *Uncomfortable*: *Achievers* are keen to improve their performance, and therefore spend time to learn how to use the app and are in control, while *Uncomfortable* are unsure if they are doing the right thing, and do not feel in control. *Quality of Interaction* is significant between two pairs of visiting behaviors: (i) *Competitors* and *Achievers*; (ii) *Adventurous* and *Achievers*. *Achievers* were more critical of the app than *Adventurous* and *Competitors,* possibly blaming their performance on the app usability. *Tiredness* is significant between *Competitors* and *Achievers* with *Competitors* feeling more tired possibly because of being constantly tense in their fighting against others. *Emotional Connection* is significant between *Adventurous* who feel more emotionally connected with the exhibition than *Achievers* who are focused on their performance.

DISCUSSION
Informed by the findings from our analysis, we now discuss the research questions proposed earlier in the paper.

1) Do different interactive strategies (game-based and story-based approaches) induce different behaviors in teenagers visiting a museum?
Even though the behavior classification is confirmed by the personality test, we have not found a dominant personality trait per behavior, but several across both apps. For example, despite the expectation that *Extroversion* could be a key factor (extrovert = game; introvert = story), we confirm, as found in [46], that a positive experience derives from a good match between the personal attitude and the type of interaction. For example, *Gamers* stuck exclusively to the app, running around the museum to accomplish tasks, while *Explorers* went beyond the apps challenges and took on more of the museum than what was strictly asked, being rewarded with a richer experience. *Uncomfortable* and *Followers* are the expression (in both apps strategies) of the

same category: teens with strong conventional and prudent traits. In the game-based strategy this typology feels uncomfortable because they are forced to act and are worried of being inadequate, while they feel at ease with the story-based strategy that ask them to go along without taking decisions, but resists the exploration of the exhibits. Different strategies also impact on the dynamics between teenagers: the game-based approach can create conflicts between two *Gamers* who both want to lead or blame the other about points lost or wrong answers. Conversely, if engaged in the story, a pair of gamers might agree in skipping content to quickly reach the end, at the cost of ignoring the information delivered and the exhibits surrounding them.

2) To what extent would different personality traits map the behavior of teenagers interacting with different strategies?
Our data show a congruence between certain personality traits and a specific strategy. However, the complexity introduced by the personality test does not yield simple matches. For example, impulsive teenagers (high level of *neuroticism*) in game-based approach tend to display an *Achievers* attitude, while if given a story-based approach show a *Skipper* behavior. Nevertheless, a similar trait could also lead to two different behaviors in the same approach, for example *conventional* teens are as likely to act as *Skippers* or *Achievers* with the story-based approach. It is therefore very difficult to pair personality traits with engagement strategies in a reliable way across the many variables. In general, we can say that a story-based is suitable to a larger set of personalities and generates less criticisms than the game-based, that fits well only the most competitive (but not when they are in the same group).

3) What are the implications for the design of story-based and game-based strategies in museums?
Different strategies can be implemented for different museums' intentions, depending on the type of experience the museum wants to craft. The combination of personality and interaction strategy generates behaviors that fits (to different degrees) the intended optimal use of the app. Overall, *Gamers* natural fit is a game-oriented app, storytelling is more suitable for *Uncomfortable/Followers*, while *Explorers* are at ease with both. Reflecting on our findings, we see that two diverging approaches are possible: to design for changing visitor's attitude vs. designing for the visitor's attitude.

Gamers
Our findings show that *Gamers* respond strongly to competition elements such as ranking, scores, or timing. If from one side this can motivate, on the other it focusses them too much on the game mechanics, neglecting the museum environment, echoing results of [11], e.g. running through the museum for the next item, prevents them to pay attention to the exhibition and can be disruptive of other visitors. Thus, games in museum should be carefully designed, time strategies or scoring points being a critical

element. How to make *Gamers* progress without rushing is an open question. Possible solutions include, reversing the time approach and let those at the slower pace win the competition, or propose games that accommodate contemplative behaviors. Puzzles could invite *Gamers* to spend time thinking and discussing the exhibits. Ranking seems important as competition and performance are key factors for *Gamers* and *Achievers* alike. However, the scoring of the performance should be based on 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.

Explorers

Our findings show *Explorers* being fascinated by both the experiences and the museum in general, being somehow the easier group to design for. *Explorers* can be leaning towards being *Achievers*, or *Adventurous*. In the latter, if their personalities show *frenemies* traits, they might have arguments along the way. Suggestions stemming from these findings point to care being taken into harmonizing the experience for the *Explorer-Adventurous* that display *frenemies* attitudes as a pair. 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 drawing an exhibit from life, or gathering some other information necessary to complete the task.

Followers

Followers' behavior could be classified as passive: they listen to the narratives in full and follow the story unfold. Interactive elements that require decision-making could be introduced to challenge and gently push them to be more engaged with the exhibition. For example, a multiple choices narrative would require visitors to decide which exhibit to visit next, hence determining where to go and what to see, for the plot to unfold. To choose implies appropriation, and in this case navigation of the museum and which exhibits to pay attention to. In this way, *Followers* create their own story while visiting. Clearly this requires the museums and the designers to create more complicated plots and more content in order to accommodate multiple storylines within the same app. Moreover, the interaction should be carefully designed so the progress of the plot cannot prescind from taking in the museum artefacts. In terms of content, we experimented with different types and lengths: Xavier and Marina fictional story unfolds in the museum garden, through fragment, where the history of the Carvalhal's palace and of the monk seal species are narrated. Inside the museum, shorter snippets are delivered by the different species displayed in the museum's cases, which unfold the mystery in the story, through gossips mixed with scientific facts about the exhibited species. Short and frequent fragments made the visit more dynamic, held interest of the *Followers*

better (avoiding skipping) and invite a wider exploration of the exhibition space, by moving more often to find exhibits that would release further story and scientific facts.

Uncomfortable

The integration of challenges (treasure-hunt and quizzes) promotes competition. The *Uncomfortable* types, who only manifested in the game-based strategy, were extremely concerned about others and worried about not being as good in understanding the game. As their classification shows, these visitors did not feel at ease, nor fully enjoyed the experience. When designing for these types, we suggest not to encourage competition, avoiding game mechanics such as timing or points, and possibly avoid referring to the experience as 'game' altogether. Because of their performance anxiety, *Uncomfortable* might not pay enough attention to tutorials and, thus, might not learn how the mobile app works. We suggest paying attention to them 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.

CONCLUSIONS

We presented the rationale and evaluation of Memories of Carvalhal's Palace, a Natural History Museum mobile experience, engaging teens through a bespoke approach: story-based (*Turning Point*) and game-based (*Haunted Encounters)*. Upon museum request, we studied 15-19 years old teenagers, visiting the museum as part of their school trip, in order to understand how they responded to the different strategies and if their personalities played a role. The recordings of their conversations provided insights on their concerns and feelings about the museum and the mobile apps. Moreover, post experience interviews and a series of quantitative measures were recorded. We crossed these results with the outcome of the personality test and propose a classification of teenagers' behaviors in relation to the museum experience and the app strategy. In summary, *Gamers* (*competitors* and *skippers*) enjoy game-oriented approaches, while *Followers/Uncomfortable* enjoy story-based. *Explorers* (*adventurous* and *achievers*) are at ease with both. In general, we can say that story-based strategies are suitable for a broader set of personalities and generate fewer criticisms than game-based strategies that fit well only the most competitive.

REFERENCES

1. Espen Aarseth. 2012. A Narrative Theory of Games. In *Proceedings of the International Conference on the Foundations of Digital Games* (FDG '12), 129–133. https://doi.org/10.1145/2282338.2282365

2. Espen J. Aarseth. 1997. *Cybertext: Perspectives on Ergodic Literature*. Johns Hopkins University Press, Baltimore, MD, USA.

3. Espen J. Aarseth. 2004. Genre trouble: narrativism and the art of simulation. In *First Person: New Media as Story, Performance, and Game*, Noah Wardrip-Fruin and Pat Harrigan (eds.). Cambridge: The MIT Press.

4. Sven Magne Bakken and Palmyre Pierroux. 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

5. John Barton and Tim Kindberg. 2001. *The Cooltown User Experience*. HP Hewlett Packard.

6. Georgina Bath Goodlander. 2009. Fictional press releases and fake artifacts: How the Smithsonian American Art Museum is letting game players redefine the rules. In *Proc. of Museums and the Web 2009*.

7. Leslie Bedford. 2001. Storytelling: The Real Work of Museums. *Curator: The Museum Journal* 44, 1: 27–34. https://doi.org/10.1111/j.2151-6952.2001.tb00027.x

8. Ian Bogost. 2010. *Persuasive Games: The Expressive Power of Videogames*. The MIT Press, Cambridge, Mass.

9. Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology* 3, 2: 77–101. https://doi.org/10.1191/1478088706qp063oa

10. Jacob Buur and Ben Matthews. 2008. Participatory Innovation: A Research Agenda. In *Proceedings of the Tenth Anniversary Conference on Participatory Design 2008* (PDC '08), 186–189.

11. Jorge Simarro Cabrera, Henar Muñoz Frutos, Adrian G. Stoica, Nikolaos Avouris, Yannis Dimitriadis, Georgios Fiotakis, and Katerina Demeti Liveri. 2005. Mystery in the Museum: Collaborative Learning Activities Using Handheld Devices. In *Proceedings of the 7th International Conference on Human Computer Interaction with Mobile Devices & Services* (MobileHCI '05), 315–318. https://doi.org/10.1145/1085777.1085843

12. Clara Cahill, Alex Kuhn, Shannon Schmoll, Wan-Tzu Lo, Brenna McNally, and Chris Quintana. 2011. Mobile Learning in Museums: How Mobile Supports for Learning Influence Student Behavior. In *Proceedings of the 10th International Conference on Interaction Design and Children* (IDC '11), 21–28. https://doi.org/10.1145/1999030.1999033

13. Vanessa Cesário. 2018. Analysing Texts and Drawings: The Teenage Perspective on Enjoyable Museum Experiences. In *32nd British Human Computer Interaction Conference*, 1–3. https://doi.org/10.14236/ewic/HCI2018.215

14. Vanessa Cesário. 2019. Guidelines for Combining Storytelling and Gamification: Which Features Would Teenagers Desire to Have a More Enjoyable Museum Experience? In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems* (CHI EA '19), SRC03. https://doi.org/10.1145/3290607.3308462

15. 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 and Digital Communication*, 127–134.

16. Vanessa Cesário, Antonio Coelho, and Valentina Nisi. 2018. Design Patterns to Enhance Teens' Museum Experiences. In *32nd British Human Computer Interaction Conference*, 1–5. https://doi.org/10.14236/ewic/HCI2018.160

17. Vanessa Cesário, Sónia Matos, Marko Radeta, and Valentina Nisi. 2017. Designing Interactive Technologies for Interpretive Exhibitions: Enabling Teen Participation Through User-Driven Innovation. In *Human-Computer Interaction - INTERACT 2017* (Lecture Notes in Computer Science), 232–241. https://doi.org/10.1007/978-3-319-67744-6_16

18. Koula Charitonos, Canan Blake, Eileen Scanlon, and Ann Jones. 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

19. Tanguy Coenen, Lien Mostmans, and Kris Naessens. 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

20. Areti Damala, Marel van der Vaart, Loraine Clarke, Eva Hornecker, Gabriela Avram, Hub Kockelkorn, and Ian Ruthven. 2016. Evaluating tangible and multisensory museum visiting experiences: Lessons learned from the meSch project. In *Proc. of Museums and the Web 2016*.

21. Riccardo Dini, Fabio Paternò, and Carmen Santoro. 2007. An Environment to Support Multi-user Interaction and Cooperation for Improving Museum Visits Through Games. In *Proceedings of the 9th International Conference on Human Computer Interaction with Mobile Devices and Services* (MobileHCI '07), 515–521. https://doi.org/10.1145/1377999.1378062

22. Allison Druin. 1999. Cooperative Inquiry: Developing New Technologies for Children with Children. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '99), 592–599. https://doi.org/10.1145/302979.303166

23. Susan Edwards and David Schaller. 2007. The Name of the Game: Museums and Digital learning Elements.

In *The Digital Museum: A Think Guide* (First Edition), Herminia Din and Phyllis Hecht (eds.). American Association of Museums, Washington, DC.

24. John H. Falk. 2009. *Identity and the Museum Visitor Experience*. Routledge, Walnut Creek, Calif.

25. John H. Falk and Lynn D. Dierking. 2000. *Learning from Museums: Visitor Experiences and the Making of Meaning*. AltaMira Press.

26. Margaret Fleck, Marcos Frid, Tim Kindberg, Eamonn O'Brien-Strain, Rakhi Rajani, and Mirjana Spasojevic. 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

27. Lewis R. Goldberg, John A. Johnson, Herbert W. Eber, Robert Hogan, Michael C. Ashton, C. Robert Cloninger, and Harrison G. Gough. 2006. The international personality item pool and the future of public-domain personality measures. *Journal of Research in Personality* 40, 1: 84–96. https://doi.org/10.1016/j.jrp.2005.08.007

28. Jonna Hakkila, Mira Alhonsuo, Lasse Virtanen, Juho Rantakari, Ashley Colley, and Timo Koivumaki. 2016. MyData Approach for Personal Health – A Service Design Case for Young Athletes. In *Proceedings of the 2016 49th Hawaii International Conference on System Sciences (HICSS)* (HICSS '16), 3493–3502. https://doi.org/10.1109/HICSS.2016.436

29. Eva Hornecker and Luigina Ciolfi. 2019. *Human-Computer Interactions in Museums*. Morgan & Claypool Publishers.

30. Sherry Hsi and Holly Fait. 2005. RFID Enhances Visitors' Museum Experience at the Exploratorium. *Commun. ACM* 48, 9: 60–65. https://doi.org/10.1145/1081992.1082021

31. Y. Ioannidis, K. E. Raheb, E. Toli, A. Katifori, M. Boile, and M. Mazura. 2013. One object many stories: Introducing ICT in museums and collections through digital storytelling. In *2013 Digital Heritage International Congress (DigitalHeritage)*, 421–424. https://doi.org/10.1109/DigitalHeritage.2013.6743772

32. H. Jenkins. 2004. Game design as narrative architecture. In *First Person: New Media as Story, Performance, and Game*, Noah Wardrip-Fruin and Pat Harrigan (eds.). Cambridge: The MIT Press.

33. Emily Johnsson. 2006. *Telling Tales: A Guide to Developing Effective Storytelling Programmes for Museums*. Museums Hub.

34. J. Jull. 2001. Games telling Stories? - A brief note on games and narratives. *Game Studies: The International Journal of Computer Game Research* 1, 1.

35. Akrivi Katifori, Manos Karvounis, Vassilis Kourtis, Marialena Kyriakidi, Maria Roussou, Manolis Tsangaris, Maria Vayanou, Yannis Ioannidis, Olivier Balet, Thibaut Prados, Jens Keil, Timo Engelke, and Laia Pujol. 2014. CHESS: Personalized Storytelling Experiences in Museums. In *Interactive Storytelling* (Lecture Notes in Computer Science), 232–235. https://doi.org/10.1007/978-3-319-12337-0_28

36. Madhuri Koushik, Eun Jung Lee, Laura Pieroni, Emily Sun, and Chun-Wei Yeh. 2010. Re-envisioning the Museum Experience: Combining New Technology with Social-Networking. In *Entertainment Computing - ICEC 2010*, 248–253. https://doi.org/10.1007/978-3-642-15399-0_24

37. Brenda Laurel. 1991. *Computers As Theatre*. Addison-Wesley Longman Publishing Co., Inc., Boston, MA, USA.

38. Jochen Martin and Christian Trummer. 2005. Personalized Multimedia Information System for Museums and Exhibitions. In *Intelligent Technologies for Interactive Entertainment*, 332–335. https://doi.org/10.1007/11590323_46

39. Paul F. Marty, Anne Mendenhall, Ian Douglas, Sherry A. Southerland, Victor Sampson, Michelle Kazmer, Nicole Alemanne, Amanda Clark, and Jennifer Schellinger. 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

40. Javier Melero, Davinia Hernández-Leo, and Kalpani Manatunga. 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

41. J. Murray. 2004. From Game-story to cyberdrama. In *First Person: New Media as Story, Performance, and Game*, Noah Wardrip-Fruin and Pat Harrigan (eds.). Cambridge: The MIT Press.

42. Julie Napoli and Michael T. Ewing. 2000. The Net Generation. *Journal of International Consumer Marketing* 13, 1: 21–34. https://doi.org/10.1300/J046v13n01_03

43. Tommy Nilsson, Carl Hogsden, Charith Perera, Saeed Aghaee, David Scruton, Andreas Lund, and Alan F. Blackwell. 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

44. Kenton O'Hara, Tim Kindberg, Maxine Glancy, Luciana Baptista, Byju Sukumaran, Gil Kahana, and Julie Rowbotham. 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

45. Mohd Kamal Othman, Helen Petrie, and Christopher Power. 2011. Engaging Visitors in Museums with Technology: Scales for the Measurement of Visitor and Multimedia Guide Experience. In *Human-Computer Interaction – INTERACT 2011*, Pedro Campos, Nicholas Graham, Joaquim Jorge, Nuno Nunes, Philippe Palanque and Marco Winckler (eds.).

Springer Berlin Heidelberg, 92–99. https://doi.org/10.1007/978-3-642-23768-3_8

46. Daniela Petrelli and Sinead O'Brien. 2018. Phone vs. Tangible in Museums: A Comparative Study. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18), 112:1–112:12. https://doi.org/10.1145/3173574.3173686

47. Palmyre Pierroux, Liam Bannon, Kevin Walker, Tony Hall, Victor Kaptelinin, and Dagny Stuedahl. 2007. MUSTEL: Framing the Design of Technology-Enhanced Learning Activities for Museum Visitors. In *Proceedings of the International Cultural Heritage Informatics Meeting (ICHIM07)*.

48. K. Poels, Y. A. W. Kort, and W.A. IJsselsteijn. 2007. *D3.3: Game Experience Questionnaire: development of a self-report measure to assess the psychological impact of digital games*. Technische Universiteit Eindhoven, Eindhoven.

49. Laia Pujol, Akrivi Katifori, Maria Vayanou, Maria Rossou, Manos Karvounis, Marialena Kyriakidi, Stamatia Eleftheratou, and Yannis Ioannidis. 2013. From personalization to adaptivity – Creating immersive visits through interactive digital storytelling at the Acropolis Museum. In *Workshop Proceedings of the 9th International Conference on Intelligent Environments*, J. A. Botía and D. Charitos (eds.). IOS Press.

50. Marko Radeta, Vanessa Cesario, Sónia Matos, and Valentina Nisi. 2017. Gaming Versus Storytelling: Understanding Children's Interactive Experiences in a Museum Setting. In *Interactive Storytelling* (Lecture Notes in Computer Science), 163–178. https://doi.org/10.1007/978-3-319-71027-3_14

51. Marie-Laure Ryan and A.-L. Rebreyend. 2013. From Narrative Games to Playable Stories. *Nouvelle revue d'esthétique* No 11, 1: 37–50.

52. Iván Sánchez, Marta Cortés, Jukka Riekki, and Mika Oja. 2011. NFC-based Interactive Learning Environments for Children. In *Proceedings of the 10th International Conference on Interaction Design and Children* (IDC '11), 205–208. https://doi.org/10.1145/1999030.1999062

53. Scott Sayre and Kris Wetterlund. 2008. The Social Life of Technology for Museum Visitors. *Visual Arts Research* 34, 2: 85–94.

54. David Schaller and Barbara Flagg. 2013. Playtesting PlanetMania: A Mobile Game for Museum Exhibits. In *Proc. of Museums and the Web 2013*.

55. Gerhard Schwabe, Christoph Goth, and Dirk Frohberg. 2005. Does Team Size Matter in Mobile Learning? In *Proceedings of the International Conference on Mobile Business* (ICMB '05), 227–234. https://doi.org/10.1109/ICMB.2005.35

56. Yao-Ting Sung, Kuo-En Chang, Huei-Tse Hou, and Pin-Fu Chen. 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

57. Vasiliki Tzibazi. 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

58. Maria Vayanou, Akrivi Katifori, Manos Karvounis, Vassilis Kourtis, Marialena Kyriakidi, Maria Roussou, Manolis Tsangaris, Yannis Ioannidis, Olivier Balet, Thibaut Prados, Jens Keil, Timo Engelke, and Laia Pujol. 2014. Authoring Personalized Interactive Museum Stories. In *Interactive Storytelling* (Lecture Notes in Computer Science), 37–48.

59. Jetmir Xhembulla, Irene Rubino, Claudia Barberis, and Giovanni Malnati. 2014. Intrigue at the Museum: Facilitating Engagement and Learning through a Location-Based Mobile Game. In *Proceedings of the International Conference on Mobile Learning 2014*.

60. E. Zimmerman. 2004. Narrative, interactivity, play, and games: four naughty concepts in need of discipline. In *First Person: New Media as Story, Performance, and Game*, Noah Wardrip-Fruin and Pat Harrigan (eds.). Cambridge: The MIT Press.