Designing Mobile Museum Experiences for Teenagers

ABSTRACT

While museums are often designed to engage and interest a wide variety of audiences, teenagers are a neglected segment. This article describes a set of findings that aids in designing enjoyable interactive experiences inside natural history museums for teenagers (15–19 years old). For this research, 223 teenagers have been involved through co-design sessions and testing of Augmented Reality prototypes (130 of these teenagers took part in a focus group as well). This work also involved 3 museums from Portugal, 12 cultural heritage professionals, and 17 master's students as sources of information who took part in different research studies. Through qualitative analysis, the findings from the studies provide a strong foundation to inform and inspire work within the emerging research field concerning museum offerings and the current teenage generation.

Keywords: museums; teenagers; visitors; user experience; co-design

INTRODUCTION

Museums maintain different ways to involve the visitor, such as wall labels, audio guides, guided tours, and brochures. However, these forms of communication are inherently limited. Wall labels and brochures might be well designed, but they are static and do not afford digital interaction. The audio guides might contain exciting stories, but they are delivered in a static way such that users cannot dynamically request more information. Human-led guided tours have a personal touch, as visitors can receive answers to personalised questions, but such tours 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 [1] and require minimal changes to an exhibition space. Furthermore, without some degree of digital interactivity, it is challenging for a museum to remain exciting and relevant to a young, tech-savvy audience.

Falk (2009) argues that museums should segment their audiences because each audience group, especially teenagers, is different regarding motivations, beliefs, and expectations of a cultural heritage space [3]. 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 museum research. At the same time, gamification and playful interaction [4] afforded by the widespread use of mobile personal devices (in museum settings) offer opportunities to attract young visitors [5], enabling a closer relationship with a museum's stories and exhibits, promoting positive attitudes about museum spaces, and creating more joyful destinations to promote meaningful informal learning combined with entertainment [6].

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 [7]. It is crucial to involve CHPs in the design process to attract teenagers, given that they are the adults of tomorrow and a future museum audience, which is currently neglected by curatorial strategies.

The main contribution of this paper is a set of findings that will aid in the design of interactive experiences inside natural history museums for the teenage audience (15-19 years old) and implications for museum management. To address this broad topic, we broke down the research into the following research questions: (i) *What type of experiences would teenagers like to have in a museum?* (ii) *Is a gamified experience important for a museum tour?* Although these research questions are broader in scope, we have studied a specific domain: high school visits from students in informatics, multimedia, and social sciences courses at a museum of natural history. We 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 in museum visits. These findings could be used as a starting point in the development of mobile museum experiences targeted at older teenagers.

MUSEUM MANAGEMENT AND VISITOR EXPERIENCE

Museums are well known as important centres of information and knowledge and hold a significant amount of power in selecting which cultural and historical stories to convey in their message [8]. Thus, museums must look closely at how their work shows up in the world. The mission of museums increasingly emphasises community development goals [9] while maintaining a focus on access to knowledge and aesthetic experience [10]. Museums should see themselves as a forum for debate [11] as their essential role is now to provide engaging, exciting experiences, education, and learning to their audiences [12].

The museum experience must be carefully framed so that visitors can make meaning from them. People seek opportunities to satisfy their curiosity and experience things that they do not usually get to see or do [13]. Curiosity accompanied by learning represents a feedback loop: "curiosity evolved in order to facilitate learning, while learning occurs in order to satisfy curiosity" [14]. When a museum exhibition presents information that enjoyably stimulates the visitor's state, the experience becomes intrinsically rewarding. Hopefully, it motivates visitors to pursue further learning [14]. On the other hand, if it does not meet the visitor's expectations, their curiosity might fade and the experience might not enlighten the visitor mentally or emotionally.

Museums are a space for enlightenment beyond formal schooling and education. The school structure is removed, which provides museum visitors with the freedom to follow their interests and curiosity [13] fostered by their intrinsic motivation [15]. Enlightenment is the intrinsically motivated process by which one gains a great understanding of something [13]. Saeter (2004) argues that museums are being Disneyfied in terms of the experience. On the other hand, Madsen and Jensen [13] balance enlightenment and experience so that users achieve enlightenment through explorative experiences. Exploration becomes relevant because it is a curiosity-driven search for facts and the visitors' interpretation of them [13]. Museum exploration requires the visitor's curiosity and free exploration to create enlightenment [14] and the assimilation of knowledge that transforms into reflective observations and abstract conceptualizations [17]. It is essential to design museum exhibitions as a space for exploration to encourage curiosity and active participation among visitors [13]; this is in line with arguments about the importance of creating space for satisfying curiosity and optimizing the potential for meaning-making [14, 15].

In order to feed the virtuous curiosity/learning loop, it is proposed that museums should be transformed into more participatory places [8], as many museums treat their audiences as passive rather than cultural participants [9]. Involving visitors might be the only way for museums to create new reflective practices for program and exhibition development to match their visitors' interests and ideas [18]. As curiosity can be aroused by objects never seen before, fascinating pictures, surprise effects, and new information related to existing knowledge, visitors risk being bombarded with stimuli and information [19].

The increased relevance of museums as a platform of informal education leads to more concrete forms of involvement for museum visitors, such as families in which parents are involved in the children's access to museum experiences [20]. Families are an important target group for museums, as a museum visit is described as "a family-bonding activity that belongs to the discourse on family time-quality" [21]. This fact implies that a generation of accustomed visitors could emerge in the future [22]. Studying the behaviour of visitors is key to understanding why and how visitors access museums [23]. Literature on museum visitors shows valuable insights into times and modes of

attention [24], behavioural typologies of visitors [25, 26], expectations [27], and social characteristics [28]. All these insights have been researched in parallel with actual patterns of behaviour of visitors in museum contexts, which prove how complex and challenging it is to capture visitors' attention and enable them to absorb basic information from the exhibitions [29].

TEENAGERS AS MUSEUM VISITORS

Teenagers are an important museum audience that is sometimes overlooked [30–32]. This exclusion has a profound impact, 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 [32]. Recent work considers teenagers as being different from both children's and adults' perspectives [33]. The teenage brain is in a position of continual change [34] and, hence, it behaves differently from those of children and adults. Much of the literature has focused on museum learning and education [12, 35–37], recognizing that outside of educational settings, teenagers are unrepresented and generally feel excluded from museums [31], having, thus, little impact on attitude and knowledge acquisition. Marketing professionals can help foster a lifelong interest in museums by exploring new and more effective channels to reach teenagers [38], as teenagers usually focus on their smartphones rather than on the museum [20]. The target audiences are the final users; hence, it is crucial to study their interests and desires, having them as 'sources of innovation' [39] and 'design partners' [40], to deploy a high quality and enjoyable product.

PLAYFUL INTERACTION IN MUSEUM SETTINGS

In 1938, Johan Huizinga wrote *Homo Ludens* [41], a book in which 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'." Play has long been accpected as a form of learning [42]. Several scholars also agree that most of the popular games are 'untapped educational resources' [43], which might provide 'a glimpse of how we might create new and more powerful ways to learn' [44]. As described by Rolling and 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".

Motivation plays a vital role in behaviour and learning outcomes in museums [12]. Hooper-Greenhill and Moussouri [46] identified different types of learning for different visitors, including children, family groups, school groups, and teenagers. When in line with school tours and curricula, educational programs significantly impact children's cognitive, social, and cultural learning [47]. Computing and digital technologies have played an important role in enabling more flexible and tailored forms of information and providing more interactivity in museums [48].

On the other hand, 'Gamification' uses elements of games for purposes other than their regular expected use as part of an entertainment game [49]. Just as there are training games, health games, and news games, there can be gameful design or gamification for training, for health, for news, and for other application areas [49] such as museums. 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 [50]. These are the first rules of gamification. Secondly, the player must continue to maintain the motivation to keep playing [50]. 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 every situation; they are also a sign of the importance of the player, it is a status symbol. The leader boards give the competitors feedback; however, they must be used with caution, as if the difference is large relative to the level of other players, there is a risk of disappointment and demotivation.

In recent decades, many game-based museum programs have been designed for different media platforms and visitor types [51]. Those games are frequently created for use with mobile devices to guide families' explorations through mystery and treasure hunt solving [52, 53] or event tasks to scaffold students' learning through school and museum contexts [54–56]. Museums are becoming

hubs where children can experience various kinds of entertainment while they enrich their knowledge and solve challenges by themselves [14]. While the use of mobile devices to enhance and enrich museum visits has a long history [57–64], the idea that entertainment and gaming can play an equal role alongside the learning mission of most museums is a more recent approach. Museums are recognized as a fertile arena for the gamification challenge [51]. 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 to correctly answer the proposed challenges. Exhibits with elements of curiosity and challenge attract pupils' attention and engage them in reflection and sustained debate [19]. Curiosity, challenge, narratives, and participation facilitate reflection and discussion among teenage visitors in exhibitions [19]. These four design principles can help create visitor experiences in line with the exhibition aims and, thus, actively participate in contemporary hot topics.

MATERIALS AND METHODS

To answer the above-mentioned research questions, this research was conducted using a twofold approach[1]. Firstly, we studied the interests of teenagers regarding how/what they would improve in a museum tour to make it more appealing to them. Secondly, we studied how museums and curators perceive teenagers as an audience group. The teenagers enlightened us on the mechanics of the experiences which would be appealing to them, while museum professionals guided us through the 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 seven studies carried out:

1) Understanding teens and their museum experiences. In this first segment, we placed teenagers as informants and developers of museum experiences. Following Druin's framework (2002), 130 teenagers acted as informants during a focus group as a means of understanding their thoughts towards, and engagement in, museum experiences (study #1) [30]. Finally, 13 teenagers worked as developers in the creation of mobile experiences for two museums (the Medicine Museum and the Engineering Museum, both from the University of Porto, Portugal), assisted by the HP Reveal Studio[2], an Augmented Reality tool (study #2) [67] (check Figure 1). Our main goal was to gather feedback and insights into how they perceive the museums' offerings as well as to understand how they think interactive technologies could enhance their overall experiences at a museum.

Figure 1. Images from Study #2. On the left, participants visit the medicine museum without any digital support; they were invited to take pictures and notes from the exhibits that would best suit their interactive prototype. At the centre, participants in the studio room develop their prototypes with computers and smartphones. On the right, one group takes a mobile tour built by another group throughout the engineering museum and check the digital information appearing in the smart- phone regarding the topographer exhibit.

2) Framework for co-designing museum mobile experiences. In this second segment, we conducted a study with 155 teenagers positioned as designers of technologies through a framework

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[1] 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 we might use the data and information gathered during the study. To protect their privacy, each participant was assigned a code number, and the collected data was recorded by this code, not by the participant's name. Their participation was voluntary. They were free to stop their participation at any point. Refusal to participate, withdrawal of their consent, or discontinued participation in the study did not result in any penalty or loss of benefits or rights to which participants might otherwise have been entitled.

[2] Unfortunately, the HP Reveal (formerly *Aurasma*), an extended reality platform by HP, shut down its services and products after two years of being in business.

[68] intended to enable teen participation in the design of mobile interpretive exhibitions through user-driven innovation (check Figure 2). Working in collaboration with the Natural History Museum of Funchal in Madeira Island, Portugal, participants were invited to get inspired by this museum and ideate a mobile and interactive experience for the venue. The data was analysed thematically according to three main topics: (i) patterns that experience designers and curators could access to understand the design features that an enjoyable museum experience for teenagers should have (study #3) [69, 70]; (ii) highlighting which kind of narratives and mechanics the mobile museum experience should follow to attract teenaged audiences (study #4) [71, 72]; and (iii) the teenagers' impression of the co-design process itself and the proposed framework (study #5) [73].

Figure 2. Three different groups discuss their ideas supported by the framework given. They were invited to discuss and write about their ideal mobile experience for the Natural History Museum of Funchal and how visitors would interact with its exhibits. Then, they were required to draw the inter- face details for the mobile experience they had previously thought for a better explanation of their concept.

3) Understanding how museum professionals see teenagers as visitors. In the third segment, we aimed to get insights from museums' Cultural Heritage Professionals (CHPs) about how they perceive teenagers in museum tours. For this set of research studies, we focused on conducting a comparative study between the views of 43 teenagers and 17 curatorship students (students obtaining a master's in Cultural Management) on enjoyable museum tours targeted at teens; for this, we used thematic analysis (study #6) [74]. To complement this topic, we also conducted co-design sessions with a group of 12 CHPs from the Natural History Museum of Funchal, which ended up in a series of tangible digital interactive prototypes that were developed with the HP Reveal Studio (check Figure 3), targeted at teenagers, and tested by both 12 CHPs and 12 teenagers (study #7) [75, 76].
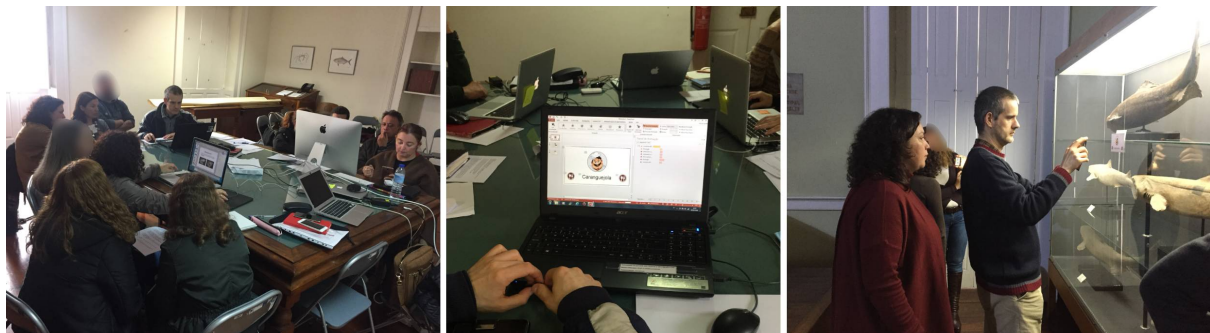

Figure 3. Images from Study #7. On the left, cultural heritage professionals from the Natural History Museum of Funchal split into groups working on their augmented reality experiences targeted to teenagers. At the centre, one computer displays the digital work (video) they were building to add to their augmented reality experience. On the right, cultural heritage professionals test their mobile experiences in groups throughout the museum.

Then, based on the findings from this set of research studies, we 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.

RESULTS

Teenagers have the perception that museums are good places for informal learning. Nevertheless, these cultural heritage venues remain unappealing to them. In essence, the results from the carried studies 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 such an institution, so as 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 [77]. 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 [51] could engage visitors within an exhibition, as people usually invest their time in events based on past experiences and personal preferences [78]. Storytelling and game-based approaches can benefit museums by promoting joyful and exciting experiences, which have the potential to support meaningful learning [6, 79], 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.

Working with teenagers to design, evaluate, or co-design can offer us a wide view of their world [80]. 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 [81]. We 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 [9], 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 [82, 83], suggested as being the core philosophy of participatory design, and ,thus, were able to produce user-oriented information technologies [84]. 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, we propose that they would enjoy visiting museums if such experiences were made available to them.

REQUIREMENTS FOR DESIGNING MUSEUM EXPERIENCES TARGETED AT TEENAGERS

In this section, we summarize the main findings encountered in these 7 studies. These findings are important because they are distilled directly from the teenagers' mindsets and reflect their everyday engagement for the creation of joyful museum experiences that would catch their attention. These findings are listed in Table 1 as a set of 24 requirements that 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, and (vii) gameplay. These topics are described in the next sections. Each requirement is referenced by a specific number from 01 to 24 (e.g., RQ_01).

Table 1. 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 covers three requirements as displayed in Table 1 (RQ_01, RQ_02, RQ_3). *Making memories* refers to making memories during the museum tour. Teenagers have a desire to speak, share, and 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 Augmented Reality 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 covers two requirements as displayed in Table 1 (RQ_04, RQ_05). *Usability & Attractiveness* 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 covers three requirements as displayed in Table 1 (RQ_06, RQ_07, RQ_8). *Exploration* 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 as well as locate the exhibits in the museum via a map. Also, teenagers would be keen on having access to unknown rooms and places in the museum.

Scientific info

This topic covers two requirements as displayed in Table 1 (RQ_09, RQ_10). *Scientific info* refers to the information the museum displays to the teenage visitor. Teenagers are interested in the museum's history and seek a general overview of the place through informal themes rather than specific knowledge through more formal themes.

Digital interaction

This topic covers two requirements as displayed in Table 1 (RQ_11, RQ_12). *Digital interaction* refers to the digital interaction encountered in the mobile experience. The current generation of teens is very fluent in the use of new technologies and does 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 covers three requirements as displayed in Table 1 (RQ_13, RQ_14, RQ_15). *Storytelling* refers to the ways in which storytelling can be used in the mobile experience.
Teenagers are keen on being the protagonists of exciting adventures – a trait that museums can harness 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 covers nine requirements as displayed in Table 1 (RQ_16, RQ_17, RQ_18, RQ_19, RQ_20, RQ_21, RQ_22, RQ_23, RQ_24). *Gameplay* 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 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, who want to be the best at their task. Collection is also a 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 for encouraging visitors to engage with museums. Teenagers wish to receive a reward when they accomplish a task: this could be in the form of receiving points, unlocking information, or increasing the level of the game. These studies highlight the importance of including search elements

and a payoff (treasure hunt) in museum experiences. Teenagers would be keen on taking some digital action such as feeding 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.

DISCUSSION

In this section, we go back to the research questions presented in the introduction and answer them based on all the results gathered, as well as state which study or situation answered them.

What types of experiences would teenagers like to have in a museum?

To answer this research question, we 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 various 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 on making memories of it by discussing it on social media platforms.

Teenagers seek **unusual events** in museums that will catch their attention and lead them to take 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 use 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 test the teenagers' knowledge. 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 achieves a significant goal (studies #2, #4).

If the experience is unique, teenagers are enthusiastic about **making memories** of this experience by taking photographs and sharing the experience on social media channels (studies #3, #6).

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 of

such technological experiences. Participants from this study see museum tours as **mundane** and unengaging activities (study #1) that do not use technologies to become more interesting (study #1). Teenagers regard 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 experiencing cutting-edge technologies that unlock digital content related to the exhibits displayed in the museum (study #3). They are also keen on viewing this **content** in Augmented Reality, Virtual Reality, 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).

When touring a museum, teenagers would also opt to use technological solutions in the form of **games and interactive stories**, as games are engaging; they indicated that museums would become 'charming places' if they employed such games (study #1).

If the technologically mediated interactive experience promotes a fun and engaging tour, teenagers will be keen on sharing 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, we report on the studies with curatorship students (study #6) and CHPs (study #7), the initial focus groups showing teenagers' perspectives 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 CHPs and teenagers agree that it could be a powerful means of boosting teenagers' engagement, even if CHPs would ascribe more importance to story-based strategies, and teenagers to game-based ones. Moreover, it is crucial to use 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). CHPs have knowledge of the content that the gamified experience should display but they do not have technological skills.

Museums must 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 (e.g., 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).

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.

IMPLICATIONS FOR MUSEUM MANAGEMENT

In this section, we identify and stress implications for museum management regarding the type of activities to pursue with teenagers, the integration of playful approaches and new technologies, and the advertisement of the museum experiences for this target group.

Teenagers can interact with the exhibits in other ways beyond the role of observers. When they are in the role of observers, they might shift their attention to their smartphones rather than to the exhibits and thereby fail to assimilate consequent knowledge from the exhibits. Museums can involve teenagers in hands-on activities in which teenagers can contribute to a museum experience not passively but by acting as informants in a workshop. These workshops can be participatory to create a museum experience incorporating not only teenagers but also curators and museum experience designers to combine the interests of teenagers within the museum experience being created. Incorporating teenagers in these workshops is very important, as museum curators usually focus more on the stories and message they want to tell and do not focus much on the type of technology their visitors would like to experience. These participatory workshops could incorporate several materials, such as videos of the exhibits in their natural habitat, to promote awareness of the species outside the natural history museum. Or museums could promote workshops outside the museum space to meet the species, such as taking a trip via catamaran to see whales and dolphins or scuba diving to see other species from the deep ocean.

For something to be appealing to our target audience, we should understand what they like, be involved in events they want, mirror that in a museum event, and hopefully get their attention in pursuing the museum activity. A museum should then provide several experiences for teenage visitors to choose from. The museum can provide several personas so that the visitor can choose one similar to their interests and lifestyle. Then, museums would trigger an experience for each persona: different personas, different aims, different enlightenments.

The objective of a museum is to disseminate knowledge, facilitate personal meaning-making, and help create public discourse about a chosen topic. Museum managers can provide experiences that provide general overviews of the scientific information and maintain informal themes that teenagers can relate to their daily lives. For example, museum curators could connect the content exhibited in a natural history museum to the traditional habits, remedies, and cuisine of the surrounding region, connecting with something that teenagers and the general public can have direct experience of. Instead of a more conventional exhibition about taxidermied species, museums can create an exhibition of the techniques to preserve endangered species. Another example is to provide awareness of preserving endangered species through playful approaches such as mini-games that are engaging and emphasize places not open to the public that teenagers should discover by embarking on role-playing so that they know how and why the museum is there today.

Addressing this target group requires special marketing efforts to convince teenagers to overcome initial barriers to visiting a museum. Museum managers can provide and advertise experiences covering Augmented Reality and virtual technologies and multimedia videos, as teenagers find the cutting-edge technologies appealing. Museums can reach teenagers by using their communication channels, incrementing the experience to be tailored to this specific public, and concentrating on a particular marketing campaign by advertising the fun that visitors are sure to have. When it comes to pursuing a visit to the museum, the act of sharing pictures through social networks not only serves as an advertisement to others but also creates memories of the experience that function as a reward for the visit.

CONCLUSION

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 so that it is tailored to this specific public but also concentrating on a specific marketing campaign by advertising the fun that visitors are sure to have.

Through mobile applications, museums can engage visitors and require minimal changes to the exhibition [1]. 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 [86], shifting the focus away from the experience and to the design itself, thereby interrupting the flow [87] 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 [88].

The findings from the conducted studies provide a strong foundation to inform and inspire work within the emerging research field concerning museum offerings and the current teenage generation. Studying teenagers' interests and needs is crucial to deploying a high-quality and enjoyable product for them. To achieve this, I suggest and emphasize that curators receive instruction in segmenting 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.

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