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Research paper

Designing with teenagers: A teenage perspective on enhancing mobile museum experiences

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ABSTRACT

Teenagers are an understudied group within the Interaction Design and Children community. Museums and cultural heritage spaces offer solutions for young children but none that are specifically targeted to teenagers. The active involvement of teenagers in the design of interactive technologies for museums is lacking further development. This paper centres on the presentation and discussion of several design sessions deployed with 155 teenage participants aged 15-19. They were asked to ideate a mobile museum experience that they would enjoy. Through qualitative analysis, the disparities in suggestions about story-based apps vs. game-based apps show that teenagers might value gamification over narratives. This work generates design recommendations for mobile museum tour guides for teenagers, to be used by both curators and museum designers in engaging teenagers in museum exhibitions. We also contrast the game and narrative mechanics produced by teenagers with what is already known. Finally, we answer the questions of how these findings align with existing museum guides for teenagers and how other designers can design with teenagers for this domain.

1. Introduction

Since the beginning of the 20th century, there has been increasing concern about the traditional exhibition and communication style of museums, which often fails to engage teenagers; hence, it inhibits the ability of museums to be fundamental institutions in a society that values cultural heritage (Hooper-Greenhill, 2001). Presently, museums are finally opening up to teenagers and young adults, taking their input seriously (Suppa, 2014; Teens programs in museums around the world – Museeum, 2020). Our work expands on this and couples it with digital interactive technologies. Technology has become a huge part of the lifestyle of teenagers, and places ranging from museums to historic sites have reacted to these times by incorporating more digital and interactive elements into their exhibitions. While the use of mobile devices to enhance museum visits has a long history (Barton & Kindberg, 2001; Cahill et al., 2011; Fleck et al., 2002; Hsi & Fait, 2005; Koushik, Lee, Pieroni, Sun, & Yeh, 2010; Martin & Trummer, 2005; Marty, Mendenhall, Douglas, et al., 2013; Sánchez, Cortés, Riekki, & Oja, 2011), the idea that entertainment and gaming can support the learning and educational missions of museums is often debated (Damala, van der Vaart, Clarke, et al., 2016; Katifori, Karvounis, Kourtis, et al., 2014; Nilsson, Hogsden et al., 2016; Xhembulla, Rubino, Barberis, & Malnati, 2014). Recent research trends support the idea that entertainment can play an equal role alongside the learning mission of most museums. Stories and games can boost the museum's learning goals while enhancing the playful aspects of the visit. Previous research demonstrates that storytelling and game-based approaches benefit museums by promoting joyful and exciting experiences, which have the potential to support meaningful learning (Edwards & Schaller, 2007; Ioannidis et al., 2013). Moreover, games (Nilsson, Blackwell, Hogsden, & Scruton, 2016; Xhembulla et al., 2014) and storytelling (Damala et al., 2016; Katifori et al., 2014) are two of the most used techniques to engage young and adult audiences as museum visitors.

Within the Interaction Design and Children (IDC) community, researchers have been exploring the active engagement of young audiences in exhibition spaces (Ardito, Costabile, & Lanzilotti, 2009; Fullerton, 2008). Research within the field of IDC is often centred on the evaluation of existing and novel interactive technologies. The majority of these works focus on children aged 4–11, which leaves a gap in the literature for older teenagers. As argued by Yarosh and colleagues (Yarosh, Radu, Hunter, & Rosenbaum, 2011), "investigating and addressing the needs of these groups would expand the body of IDC work and provide avenues for new insight and innovation". Additionally, Katterfeldt and colleagues (Katterfeldt, Zeising, & Schelhowe, 2012) argued that this target group "requires more attention in research and there is a need for appropriate methods to involve them in design processes".

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As pointed out by Pierroux et al. (2007), the creation of links between the knowledge of the exhibits represented in the museums and the visitors' daily practices is a central challenge regarding the exhibition as a product. The application of digital technologies in museums to engage young audiences in particular has been considered in recent IDC literature (Cahill et al., 2011; Druin, 2001; Hall & Bannon, 2005; Horn, Solovey, & Jacob, 2008). However, according to Roussou and colleagues (Roussou, Kavalieratou, & Doulgeridis, 2007), exhibits and educational initiatives for children and teenagers are created without involving them, except for some projects (Broadbent & Marti, 1997; Culén, Bratteteig, Pandey, & Srivastava, 2013; Cullen & Metatla, 2018; Schaper, Iversen, Malinverni, & Pares, 2019; Taxén, 2004) that invite children to engage in co-design processes and benefit from their natural expertise and motivations (Schaper et al., 2019). Co-designing, or participatory design, with children is a lengthy process: Cooperation between intergenerational teams is a process that extends over time. However, this partnership is often misunderstood by designers as, in some cases, designers include children as users of their own ideas, thus not giving them any real power (Culén et al., 2013).

Moreover, according to Falk (2009), the so-called "one size fits all experience" does not apply to most museum visitors. The same can be said about "generation Z" (13- to 18-year-olds), which is seen as quite different from previous generations, particularly regarding beliefs and behaviours (Wikia, 2013). Several museums offer differentiated guided tours for children and adults, but generally there is a lack of appropriate guidelines for the teenaged generation. In fact, Tzibazi (2013) identifies this teenage group as an audience that is often excluded from a museum's curatorial strategies. Hence, this action has a profound impact when one considers the design of an engaging experience for an exhibition. As a consequence, the older teenage audience (aged 15 to 19) usually does not see museums as engaging places (Cesário, Coelho, & Nisi, 2017b). Tzibazi (2013) challenges this gap by proposing the involvement of teenagers through participatory action research as a technique for gathering their ambitions and interest regarding museums. The target audiences are the final users, and they should be given a "voice" Simon (2010); hence, it is crucial to study their interests and desires to deploy high-quality and enjoyable products.

In this paper, we describe how we took on a similar challenge, conducting a design workshop with teenagers, in collaboration with the Natural History Museum of Funchal (NHMF), in Madeira Island, Portugal. We generate design recommendations for mobile museum tour guides for teenagers, to be used by both curators and museum designers in engaging teenagers in museum exhibitions. NHMF is a very traditional museum full of rooms displaying cases and taxidermized animals described by labels. This work is an attempt to address the museum's concerns about making the museum interesting and relevant for teenagers from 15 to 19 years old who have already visited the museum once, as part of their school field trips. By studying this audience and understanding its needs and desires, we distilled insights for the design of enjoyable museum experiences for teenagers.

The overall project was articulated in five phases. In Phase 1, we conducted a set of design workshops in which 46 groups of teenagers (155 participants) created concepts for interactive experiences on mobile devices for the NHMF, acting as *informants* to us, the researchers of this project. In Phase 2, we synthesized the data gathered from the workshops through thematic analysis. In Phase 3, the results from the analysis inspired the design of two different experiences: one centred on gaming and one centred on storytelling. In Phase 4, we evaluated the apps with respect to the personality of the visitors, classes of teenagers in an educational school trip, usability of the apps, and engagement during the museum tour (159 participants). Here, teenagers acted as *users* by testing the prototypes that we created, inspired by the results of Phases 2 and 3. Finally, Phase 5 will be a participatory approach involving teenagers, curators, and museum designers as *design partners* who re-design a common prototype together. In the scope of this paper, we look at the first two phases of the process: the deployment of workshops and the consequent analysis of the results, reflecting on the results and distilling insights from the experience. The results from Phase 3 (Cesário, 2019; Cesário, Olim, & Nisi, 2020; Cesário, Trindade, Olim, & Nisi, 2019; Nisi, Cesario, & Nunes, 2019) and Phase 4 (Cesário, Petrelli, & Nisi, 2020) of the process have already been published, and Phase 5 remains future work.

Throughout this paper, in particular, we report on the field study – Phase 1 – on exploring and identifying which mobile experiences teenagers wish to have during a museum visit, with enjoyable user experience emerging as more sought after than a specific learning-oriented experience. We then describe the analysis conducted – Phase 2 – and report on the results in terms of codes and themes regarding game mechanics and narratives encountered in the mobile experiences ideated by the teenagers. Finally, we build on those results to discuss and inform findings and mechanics that may help museum experience designers and curators better design for teenagers — a challenging audience different from previous generations (Wikia, 2013) and often excluded from a museum's cultural strategies (Tzibazi, 2013); consequently, they do not see museums as interesting places (Cesário et al., 2017b), as the methods used to reach this audience and engage them in museum activities might not be appropriate.

2. Related work

In this section, we report on some techniques for designing with and for teenagers. We then touch upon playful interaction and entertainment in museums, focusing on examples with mobile apps. Finally, we cover different popular forms of game mechanics and narratives in gaming.

2.1. Designing with and for teenagers

There is little literature on designing for and with teenagers. As addressed by Read et al. (2011), some of the reasons are: understanding design for non-adults is still entirely new, and thus there is some catching up to be done, and accessing teenagers is quite difficult, as the worlds in which they live are quite difficult to enter. Another challenge of designing with teenagers is logistical, as teenagers are often busy with extracurricular activities such as sports, after-school clubs, and part-time jobs (Read et al., 2013; Yip, Foss, & Guha, 2012), making it hard for them to find time to join design activities. One research project by Pazmino, Slattery, Lyons, and Hunt (2015) tackled this challenge by using technical and sociotechnical systems theory to guide the compression of design activities down to a single session, such as Accelerated Technological Participatory Design (ATPD) and Sociotechnological Participatory Design (ASPD). In ATPD (Pazmino et al., 2015), teenagers work in groups and keep their idea generation and design creation tightly tied to specific functionalities and features. On another hand, ASPD Pazmino et al. (2015) was conducted as an improvement to ATPD and was intended to improve the relevance of teenagers' design ideas to expert-defined tasks by adding a sociotechnological framing to the design methodology. This combination of social interaction with a facilitator and with technological interaction is meant to better situate technology usage in a real context. However, it limits the open-endedness of the scenario while still honouring participant concerns. The main

concern that authors found with regard to the ASPD methodology was that the sociotechnological framing, the inclusion of adults and domain experts, might have caused the teenagers to overly constrain their ideas and show less creativity. The authors argue that participatory design, if applied to appropriate problems, still has value.

Other challenges are related to adolescence as a stage in human psychosocial development. For example, teenagers may not actively participate in design research because they do not feel capable of providing adequate data to researchers. They are also uncomfortable about the research environment or concerned about appearing "different" (Isomursu, Isomursu, & Still, 2003, 2004; Poole & Peyton, 2013). Literature sheds light on how to counteract this reluctance and engage teenagers in generating design solutions, allowing for workable designs in a short timeframe. Iversen, Dindler, and Hansen (2013) have some ideas for motivating teen engagement, which they related to Cultural-Historical Activity Theory (CHAT) as a theoretical basis. They proposed CHAT as an approach to motivate teenagers in design activities, identifying a range of tools to be applied, such as rewards (material goods given to teenagers to carry out the design interventions), storytelling (the opportunity to communicate their own experiences), identification (t-shirts and name tags), collaboration (between teenagers), endorsement (underlying the importance of teenagers being the experts in the design process), technology (digital devices and social networks), and performance (in front of other teenagers). However, the effect of such tools on motivation varies significantly: What is more valued by some can be less valued by others. These disagreements about the features not only are related to teenagers acting in the design activity but may be understood in relation to teenagers' hierarchy of motives. With this research, we tried to access teenagers by entering their world, on a scholastic approach, inserting this research into a class/activity they take part in on a regular basis.

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

Furthermore, the user-driven innovation method plays an important role in involving teenagers in the design of user experiences for museums (Cesário, Matos, Radeta, & Nisi, 2017). This method is used mostly by industry (Buur & Matthews, 2008) and positions users as a "source of innovation" (Holmquist, 2004). According to Chang and Kaasinen (2011), it is important to adopt user-driven innovation approaches to capture user ideas that can be worked on further with designers. These face-to-face approaches have the power to facilitate participation as well as allow HCI researchers to gather the information that best translates the "user's everyday experiences" (Chang & Kaasinen, 2011).

Given that there is little literature on designing for and with teenagers, understanding design for non-adults is still entirely new (Read et al., 2011). Teenagers do not feel capable of providing adequate data to researchers, being concerned about appearing "different" and uncomfortable with the research environment (Isomursu et al., 2003, 2004; Poole & Peyton, 2013). Therefore, this target group is difficult to reach. However, like any other group, teenagers have a lot to say that is worth listening to, specifically regarding the design of museum exhibitions that they might not find appealing. We believe that employing a user-driven framework to gather teenagers' ideas on the museum topic by designing a common prototype, enabling them to act as *informants* and *sources of innovation*, can counteract this reluctance and engage teenagers in generating design solutions, allowing for workable designs in a short timeframe, as suggested in Iversen et al. (2013). Not only is it crucial to address the needs of this group to expand the body of IDC work (Yarosh et al., 2011) but also, as suggested by Druin and colleagues (Druin, 1998), working with this group can help us establish new methodologies to involve them in design processes (Katterfeldt et al., 2012).

We mirror the ATPD technique (Pazmino et al., 2015) by having teenagers work in groups to keep their idea generation specifically focused on enjoyable features they would like to see in a museum. Like the ASPD technique (Pazmino et al., 2015), our method had a Digital Interactive Media researcher (the first author) acting as a facilitator. We also used the features of storytelling, collaboration, and endorsement from the CHAT theory (Iversen et al., 2013). The reader can find more details about the application of these techniques in Section 3 — Material and methods.

2.2. Playful interaction and entertainment in museums

Mobile devices can add to the museum visit (Cesário, Coelho, & Nisi, 2017a; Cesário, Petrelli et al., 2020; Cesário, Radeta, Matos, & Nisi, 2017; Wessel & Mayr, 2007) and induce interactions between visitors and exhibits that are not interactive (Yatani, Sugimoto, & Kusunoki, 2004). They are considered different experiences that help in navigation inside the museum, to get information by solving problems, exploring different areas, and interacting with virtual characters (Cesário, Olim et al., 2020; Cesário et al., 2019; Laine, Sedano, Joy, & Sutinen, 2010), which inspires visitors to more proactively explore the museum rooms (Cesário, Petrelli et al., 2020; Cesário, Radeta et al., 2017; Yatani et al., 2004). Devices should assist the visitors, not become the main part of the visit (Cesário, Radeta et al., 2017; Wessel & Mayr, 2007). The system should be aware of the exhibits and make a connection between these objects and the virtual guide, which should be unobtrusive to the learner (Laine et al., 2010), as well as provide specific on-demand information for users who know a lot, and target content to involve and appeal to visitors who know less (Bellotti, Berta, de Gloria, & Margarone, 2002). Designing an experience in the context of a museum is not an easy task, as mobile museum applications are considered a "throw-away interface" — an interface to use once for an hour or two. Hence, it must be highly affordable and intuitive at first sight. To achieve this goal, it is important to foresee design and usability issues as a form factor for design, such as (i) issues to guarantee learning, (ii) immersion in gameplay and the social dimension, (iii) simplicity of the device and mobile interface, and (iv) lonelier role of the visitor. Hereinafter, we explain these issues in detail.

Mobile devices in museum contexts can be very appreciated by visitors, as they are usually deeply immersed in the gameplay (Cesário, Radeta et al., 2017; Cesário et al., 2019; Laine et al., 2010; Nisi et al., 2019). These interventions should be designed to offer a context to the visitor such that exhibit information becomes meaningful and useful, as visitors will be using this information to carry out the visit through the mobile device and achieve its goals (Bellotti et al., 2002; Yiannoutsou, Papadimitriou, Komis, & Avouris, 2009). Thus, the information displayed should be something that visitors can play and think with in a focused way. Moreover, (Lyons, 2009) found that making individuals'

performance public can encourage all group members to participate in a joint activity, thereby discouraging social loafing. The technology and design can sometimes support and invoke interaction and collaboration between the visitors of the museum to perform a given task (Cesário, Petrelli et al., 2020; Cesário, Radeta et al., 2017; Yatani et al., 2004; Yiannoutsou et al., 2009) but can also encourage competition between users and pairs. The ability to verify the actions of other visitors can encourage them to collaborate, as they would like to achieve the same goals (Lyons, 2009) or simply compare their achievements (Yatani et al., 2004).

Furthermore, there are urgent issues to consider when designing these "throw-away interfaces". When visiting a museum, young visitors have little time, so we should minimize usability issues as a starting point. Also, the device should be familiar to them. The system's complexity must be hidden, requiring no user effort — the mobile device and app interface should be as simple and intuitive as possible (Bellotti et al., 2002; Laine et al., 2010). Technical and usability issues can be reduced by choosing a device that the visitor will be conformable using and that has a large screen that can accommodate larger buttons, and more resources (RAM and CPU), as well as a network that covers the entire exhibition area (Laine et al., 2010; Suzuki, Hatono, Ogino, et al., 2009). The interface must be kept as simple as possible — each option should be carefully considered as to whether it makes sense and can be used by a variety of visitors (Laine et al., 2010; Wessel & Mayr, 2007). Small buttons and text (Laine et al., 2010; Wagner, Schmalstieg, & Billinghurst, 2006) make it impossible for users to manipulate objects. Also, the amount of content added to the screen should be considered, as large amounts of text, images, and multimedia can make the screen look busy (Laine et al., 2010). Video information is less disturbing when the screen size is limited (Bellotti et al., 2002). The device should support the native language of the visitor, and all tasks and stories should be appropriate for museum and personal contexts (Ceipidor, Medaglia, Perrone, De Marsico, & Di Romano, 2009; Laine et al., 2010). Also, the narrative should be adapted to be dynamic and responsive to the actions of the users (Cabrera, Frutos, Stoica, et al., 2005; Cesário, Olim et al., 2020). Furthermore, Bellotii and colleagues found that a multimedia guide can discourage visitors from reading the stationary panel texts (Bellotti et al., 2002).

The use of a mobile guide can make the visitor more attentive to what happens not only on the mobile device but also on the museum premises. However, it also makes them lonelier (Aoki et al., 2002; Bellotti et al., 2002; Hsi, 2003; Lyons, 2009). In addition, while mobile devices can motivate users to try new activities, users can also find the experience to be socially and physically isolating. Headphones tend to isolate users, limiting their ability to listen and talk to others (Bellotti et al., 2002), which would be distracting or "feel wrong" (Aoki et al., 2002).

We are motivated to focus on mobile devices to empower museums that do not make use of interactive technologies (Yatani et al., 2004). Still, mobile devices should assist the visitors by connecting the exhibits and the mobile guide (Laine et al., 2010), not serve as the central part of the museum tour (Cesário, Radeta et al., 2017; Wessel & Mayr, 2007). The information provided by the mobile guide should be meaningful and valuable and, in some cases, invoke a social dimension between the visitor, museum exhibits, and other visitors (Cesário, Petrelli et al., 2020; Cesário, Radeta et al., 2017; Yatani et al., 2004; Yiannoutsou et al., 2009), which in some cases could promote competition between visitors. Our design workshop teenage participants are aware that they would have little time to visit the museum; thus, the mobile app should be easy to use (Bellotti et al., 2002; Laine et al., 2010). They do not get into the level of detail of how little or big the buttons are to facilitate interaction within the mobile device (Laine et al., 2010; Wagner et al., 2006). However, they are aware that all content should be appropriate for museum and personal contexts (Ceipidor et al., 2009; Laine et al., 2010). Since the NHMF does not have stationary panel texts but only labels with the names of the exhibits, we will not have problems discouraging visitors from reading such panels (Bellotti et al., 2002). Still, at Phase 1 of this project, which is reported in this paper, we cannot guarantee that the ideas from our teenage participants will be socially and physically isolating, which could be distracting for visitors (Bellotti et al., 2002). Hence, Phase 4 will evaluate the apps made in Phase 3 and verify these aspects.

2.3. Game mechanics and narratives in gaming

Schell (2008) formulates a definition of games based on four elements, known as the elemental tetrad: mechanics, narrative, technology, and aesthetics. All these elements together make the game work as an experience generator. MDA (Mechanics, Dynamics, and Aesthetics) is a formal approach to understanding games, one that attempts to bridge the gap between game design and development, game criticism, and technical game research. Besides the common formal game elements – rules, resources (currency, actions, power-ups, inventory, special terrain, time), conflict, boundaries, space, objects and states, skill, and chance (Fullerton, 2008; Schell, 2008) – for most players, something else must draw them in and allow them to connect emotionally with the experience (Fullerton, 2008). This emotional connection could happen through dramatic elements such as challenges, play, premise, characters, and story. Creating conflict challenges users, as it fosters tension while they work on their own to resolve problems and varying levels of achievements or frustrations. When users talk of challenges in a game environment, they are speaking of tasks that are satisfying to complete, creating a sense of accomplishment and involvement (Fullerton, 2008). The constraints of rules and procedures are the fixed structure, and the play within that structure gives users the opportunity for emergent experience and personal expression. The premise where the game happens creates engagement, which gives a context to the formal elements. Without a dramatic premise, many games would be too abstract for players to become emotionally concerned about their outcome. Some games engage players emotionally by using the power of story within their formal elements. Like the outcome of a game, the outcome of a story is uncertain, but it is resolved over time. The audience internalizes the story's events and empathizes with its movement toward resolution by identifying with a character and the outcome of their goals. There is still much debate over the relationship between story and gameplay. Some people are story-oriented and believe a game will ruin a good story; on the other hand, some people are more game-oriented and feel that a game with strong storytelling elements is somehow cheapened (Schell, 2008). Still others prefer a middle approach such as "Story and gameplay are like oil and vinegar. Theoretically they don't mix, but if you put them in a bottle and shake them up real good, they're pretty good on a salad" (Schell, 2008).

Previous research demonstrates that storytelling and game-based approaches benefit museums by promoting joyful and exciting experiences, which have the potential to support meaningful learning (Edwards & Schaller, 2007; Ioannidis et al., 2013). Cabrera and colleagues (Cabrera et al., 2005) built an interactive museum guide called *Mystery in the Museum*, at historical/cultural museums, which allowed students to play and perform tasks related to certain exhibits. In this activity, groups of students collaborate to solve a mystery inside the museum, interacting through mobile devices. Each group receives different pieces of information through the mobile device and plays a role in the

story. At the end of the visit, they must join together and discuss the different clues they have collected, rebuilding the story and trying to solve the mystery. In this experiment, some students (13–19 years old) lost interest in the interactive guide due to the complexity of the tasks, while others switched the focus from the displayed exhibits to the handheld computers. *Ghost Detector* (Nilsson, Blackwell et al., 2016) is a story-driven and educational location-based museum game for children that utilizes beacons. In this game, ghosts of various museum exhibits appear on the screen of the young visitors' mobile devices and challenge children to find the exhibits that the ghosts represent. During an evaluation of this game, children were observed running through the corridors, paying attention to the feedback on the smartphone as well as the exhibits surrounding them. This study highlights that the introduction of the ubiquitous game undoubtedly influenced that level of excitement and engagement with the museum premises. *Intrigue at the Museum* (Xhembulla et al., 2014) is a plot-driven mobile game for children structured around exploration and task performance. It is a single-player game whose plot invites visitors to search for a thief in the museum among a set of virtual characters. Clues are given to the players as they solve riddles after scanning tags deployed in the building. Following a constructivist approach, the game allows children to freely explore the museum environment, according to their interests and agenda. This paper shows that location-based mobile games might represent a relevant learning resource in a museum setting while promoting engagement and entertainment. *Ocean Game* (Cesário, Radeta et al., 2017) explores a natural history museum's content through proximity beacons and visual cues in the form of descriptive icons representing each species to locate the content. When children and teenagers (9–11 years old) are near the icon/sticker representing the artefact, the system will signal the presence of content. In this instance, a short animation appears on the smartphone screen, suggesting that key information regarding the animal/artefact is present. The game ends when all the species are collected and quizzes, one per species, are answered. This study highlights that *Ocean Game* is more engaging and enjoyable than a traditional guided tour. However, guided tours did support rich social interaction amongst children and, therefore, excitement, as they were touring the museum in a group while the place-based game aspect of the game stimulated several specific behaviours in the children — namely, competition and collection.

Narratives and game mechanics must be carefully designed to engage young visitors in museums and to not create tensions between the gaming and learning aspects of the experience. The careful design of technology enhances activities and can therefore either promote engagement with the museum content or create tensions and discrepancies rather than alignment between the young visitors' engagement and entertainment and the learning goals of the museum. These visitors could become more interested in collecting icons and points and completing the tasks as fast as possible than in observing the artefacts.

This paper adds to the existing knowledge on game design and mechanics in museum spaces for teenagers, distilling recommendations for curators and museum designers in designing mobile tour guides for and with teenagers. While museums are often designed to engage and interest various audiences, teenagers seem to be a difficult audience to engage and, at the same time, a neglected typology of visitors for cultural heritage sites. To date, museums have reached out to specific audiences in the form of surveys and questionnaires. To obtain relevant information and support the design of exhibitions and interpretive experiences, this process has followed chiefly a top-down approach (Simon, 2010). This paper positions a group of teenagers as sources of information. The target audiences are the final users; hence, it is crucial to study their interests and desires, using them as "sources of innovation" (Holmquist, 2004) to deploy a high-quality and enjoyable product regarding game mechanics and narratives in gaming.

3. Material and methods

This research focuses on generating design recommendations for mobile museum tour guides for teenagers. It is an exploratory paper edging towards a formative study conducted by HCI researchers to generate ideas for museum experience designers and curators to prompt teenagers to visit these institutions, as well as the IDC community working with teenagers and museum experiences. Based on the literature review, this topic is relevant for the IDC community, as researchers have been exploring the engagement of young audiences in exhibitions (Ardito et al., 2009; Hall & Bannon, 2005), and it engages children aged 4–11 – not older teenagers – in design processes to benefit from their motivations regarding the concept being designed (Schaper et al., 2019). Moreover, working with teenagers in designing, evaluating, or co-designing something can offer a plethora of views of teenagers' world (Druin, 1998). With the current problem statement and possible strategies to counteract the problem of teenagers being excluded from a museum curatorial perspective, we envisage answering the following research question: *Which design recommendations can we generate for teenagers' mobile museum tour guides by exposing their views on enjoyable museum tours?* We foresee grasping teenagers' interest in the features that they would like to add to a museum experience for it to be more enjoyable and, hence, understanding whether these features are akin to what is already known in gaming and narrative mechanics.

We believe that employing a user-driven innovation method at Phase 1 of this project will be relevant in order to gather teenagers' ideas on the museum topic by having them design a common prototype. In Phase 1, teenagers are involved only in the ideation phase, acting as *informants* rather than *design partners* of an adult: They design alone in groups. Phase 2 (data results) and Phase 3 (creation of an expert prototype) do not involve teenagers; they are involved as *users* in Phase 4. Furthermore, Phase 5, still in development, involves mutual learning among teenagers, curators, and museum designers in which not only do curators and designers learn from teenagers but also teenagers learn from designers and curators. While in Phase 1 we are mining teenagers for design ideas, employing them as *informants* and *sources of innovation*, in Phase 5 they are empowered by co-designing with experts to build a common prototype. This specific paper contributes to the body of work on teenagers aged 15–19 as *sources of innovation*.

The research method applied to the current work was inspired by the CHAT approach (Iversen et al., 2013), the technological strategy ATPD (Pazmino et al., 2015), and the sociotechnological one ASPD (Pazmino et al., 2015). We mirror the ATPD technique (Pazmino et al., 2015) by having teenagers work in groups to keep their idea generation specifically on enjoyable features they would like to have in a museum. Similar to the ASPD technique from the same authors (Pazmino et al., 2015), our method had a Digital Interactive Media researcher (the first author) acting as a facilitator. However, to prevent teenagers from feeling overwhelmed by the researcher, this work involved only walking around the classroom to check on each group and discuss with them their ideation and design process, not intervening in the current ideas that were being generated. We also used the features of storytelling, collaboration, and endorsement from the CHAT theory (Iversen et al., 2013). Teenagers were asked to talk about their regular museum visits and to engage in collaborative

activities – writing and designing the mobile museum concept – and were endorsed regarding their expertise as being teenagers and an important group to be engaged in museum activities. The other features from the CHAT were not used, as we could not do the following: pay teenagers to participate in the activity (rewards); use prompts to prime their identities (identification), as they were in a class setting and knew each other; allow performance in front of peers due to time constraints (performance); or use technology such as social networks and digital devices, as the activity was for them to conceptualize the mobile museum tour in a short period of time.

For this purpose, we used a *Concept Sheet* from a user-driven innovation framework presented in Cesário, Matos et al. (2017), that positions teenagers as informants and "sources of innovation" (Holmquist, 2004). This *Concept Sheet* encompasses three probing questions that help users write about their personal opinions and feelings, thereby promoting critical thinking among them. Users fill it in by sketching a concept of an enjoyable mobile museum tour. It asks users not only for a possible narrative underlying the mobile experience but also about how the exhibits will interact with the proposed narrative, and it provides a step-by-step tutorial to better explain how visitors would pursue this experience. By working in groups and filling out the proposed sheet, teenagers play an active role in creating and developing ideas (acting as informants and sources of innovation). The researcher has a more passive role in guiding the participants' voices through the predetermined schedule for the session, as well as helping the teenagers with the logic of the concepts they proposed. We engaged 155 participants in short bursts of design workshops guided by this *Concept Sheet* to gather ideas that would be examined later for trends, following Hakkila and colleagues' methodology (Hakkila et al., 2016). We then focused on the standards of teenagers in the creation of concepts related to their ambitions and interests regarding enjoyable mobile museum experiences. We used the data from the sessions to gather feedback and reveal insights into how teenagers think mobile interactive technologies could enhance their overall engagement in a museum experience. We followed advice from Druin (1998, 1999) on how to work with young participants, such as wearing informal clothing, sitting instead of standing, asking the participants for their opinions and giving them time to articulate those opinions, using informal language, and taking notes discreetly. We borrowed this technique because we wanted to be close to the participants, given the fact that the participants would be in a scholastic setting (detailed in the next section).

However, the sample of this study cannot say what teenagers in general like. Rather, it provides insight into what this specific group came up with within this particular study on gaining design insights when listening to a group for which we aim to design. Hence, from now on, we refer to the teenage participants of this study as mere participants and not just teenagers.

3.1. Sample

This research was conducted on Madeira Island and in Portugal mainland for 4 months in 2017 (March, May, July, December). The researcher approached (i) two secondary schools in Madeira, (ii) students doing summer internships at our research institute (ITI/LARSyS), and (iii) students taking part in a summer camp at the University of Porto. To conduct the studies with teenagers at the schools and at our institute, it was necessary to get approval from the Regional Educational Department in Madeira, and an agreement with the schools was reached. Regarding the studies at the summer camp, it was necessary to obtain the approval of the university. All the participants were enrolled in a secondary public school (10th to 12th grade) studying Informatics and Multimedia courses, and were told they would be involved in a lecture about museums followed by some practical group work. Then, written consent was obtained from all of the participants' legal guardians. In total, 155 participants aged 15–19 took part in the studies (Table 1). All of the participants from Madeira Island had visited the museum at an early age but the participants from the summer camp, because they were not from the island, had never visited this specific natural history museum. However, at some point in their lives, they had visited a natural history museum not empowered with any technology in their city, being very similar to the museum of this case study located on Madeira Island. Although this work was an attempt to address the NHMF's concerns about making the museum interesting for teenagers, an important aspect of the study was that participants had visited a natural history museum – and not necessarily the NHMF – at some point in their lives. Each workshop session was performed in a single 01h 30 m slot and each participant participated in just one slot. In each slot, the students were divided into groups (5 to 8 groups per slot), resulting in a total of 46 groups with an average of 3–4 students per group mixed by gender, given the fact that females were underrepresented in the sample (Table 1). Because the participants knew each other from their classes, they chose their own groups. These sessions were facilitated by one member of our research team, the first author.

Table 1
Graph containing the sample of the participants split by age and gender.

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

3.2. Procedure

The sessions took place in classrooms and took 01h 30 m to complete. The schools, the institute, and the summer camp made regular classrooms (chairs and tables) available for the study. We divided this section into the four main topics approached in the sessions conducted: (i) ice-breaking activity, (ii) oral introduction, (iii) design workshop, and (iv) evaluation.

Ice-breaking activity. At the beginning of the design workshops, the researcher conducted focus groups with the participants to collect information about whether they liked to visit museums, in what situations they usually went to museums, and what kinds of experiences they wanted to have inside museums. The researcher asked these questions and gathered notes only on the verbal expressions of the participants. In total, 667 expressions were gathered; these were analysed and already published in Cesário et al. (2017b). These focus groups were meant to function as an ice-breaking activity and to access participants' experiences with mobile tours. Participants had poor knowledge about museums that use technology to promote museum tours – they were "*not aware of any*" – and had no experience designing or experimenting with gamified mobile tours. Although all thought museums were good places for informal learning, they "*usually don't go there frequently*" as these venues remain unappealing. Participants described museums as "*boring*" places.

They desired to experience the museum through interaction and games — "*It would be fun to explore a museum through a game. It would be engaging because the games are engaging. Hence the museums will become charming places*"; "*I could go to a museum taking a tour by a digital game to have fun and to be the best and*

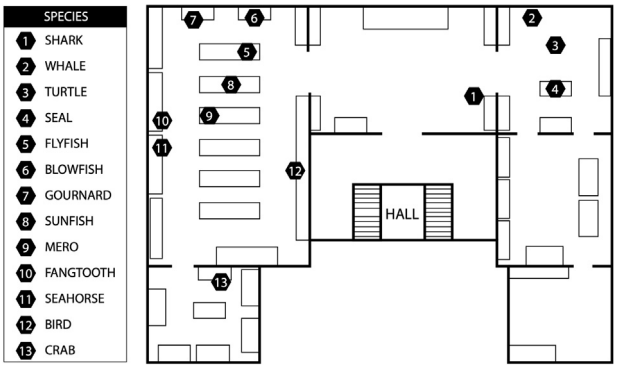

Fig. 1. Map of the museum that was shown to the participants.

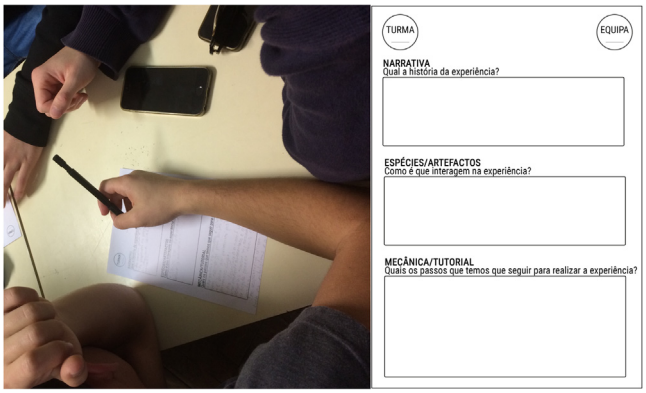

Fig. 2. Left: Picture of one of the groups in the sessions held. Right: *Concept Sheet* from Cesário, Matos et al. (2017) in Portuguese (translation to English in the text above).

also the fastest one!". They also indicated that interactive content, augmented reality, taking pictures, and sharing on social media were appealing methods of enhancing their visitor experience — "*Of course I would visit a museum empowered with technology*"; "*If I saw a picture taken in the museum in my Facebook or Instagram, I would go there for sure to try it*"; "*Taking pictures would be fun also as Snapchat does*". Hence, the participants did not have prior experience in designing or experimenting with gamified mobile tours, and the role of the researcher in the design workshop that followed was to support participants in forming such ideas about museum experiences crafted as enjoyable. At the very end, participants were asked to think about how several technologies could play a relevant role during a visit to the museum. For example, Near Field Communication (NFC), Radio Frequency Identification (RFID), Quick Response Code (QR Code), Augmented Reality (AR), Mobile Virtual Reality (MVR), and Proximity Beacons were provided as a set of examples. These technologies were explained in depth along with examples of their usage.

Oral introduction. The researcher presented the main goal of the workshop, which was to enhance museums through mobile technology. The NHMF was then introduced as an example to prompt the participants' imagination through a series of photos of the museum's collection (marine and mammal species, geological, and reptiles). The researcher stated that it was a venue with a plethora of [region name]'s fauna-rich content. However, the museum building itself is quite old-fashioned, lacking the technology to engage visitors in interacting enjoyably with the exhibits. The map of the museum was displayed through a picture highlighting 13 numbered points of interest related to the main exhibits of marine species. The researcher also stated that those main exhibits could be the subject of the mobile interactive experience (Fig. 1) and that when split into groups, the participants should think, discuss, reflect, and write, on the *Concept Sheet*, their own needs, values, and motivations in experiencing mobile museums. As guidance, participants were explicitly asked to derive activities that they would enjoy having in a natural history museum tour, and not to formulate an activity in general.

Design workshop. Finally, the students were divided into groups, given one working sheet per group, and involved in a 30-minute design workshop (Cesário, Matos et al., 2017). The *Concept Sheet* contained three probing questions to be filled in by the group's participants regarding the general idea behind the whole experience (Fig. 2). To structure participants' answers about how they would communicate to us their ideal enjoyable museum experiences, motivated by their own choices, these probing questions focused on the link between narrative and exhibits and how it unfolds in the museum. These probing questions are detailed below along with the instructions that the researcher gave for answering them.

(i) *Narrative: what is the narrative underlying the experience?* — The researcher asked the participants to fill out this section with the description of the experience they envisioned in order to communicate how the experience would be conducted in the museum. This description will function as a summary of the participants' ideal mobile museum activity to help the research team quickly ascertain the experience's purpose.

(ii) *Species/Exhibits: how do visitors interact with the museum's exhibits*? — The researcher asked the participants to fill out this section by detailing how the species/exhibits of the museum would be part of the experience described before and how they would be interacting with the mobile application, the visitor, and the museum.

(iii) *Mechanics/Tutorial: which steps do visitors have to take to complete the experience?* — The researcher asked the participants to fill out this section by detailing which steps the visitor would need to follow to pursue and complete the experience. In other words, which actions would need to be taken to reveal specific feedback and/or other steps to follow to reach the end of the experience?

When the groups were settled, they were advised to brainstorm at the beginning of the design process to encourage a "feeling that everything was possible", as advised by Druin and colleagues (Druin, Bederson, Hourcade, et al., 2001). During the design process, the researcher continuously walked around the classroom to check on each group, taking notes on the participants' behaviour while supporting them in forming ideas and discussing the ideation and design process with them.

Evaluation. During the design workshops, the researcher took notes on some of the participants' remarks. The participants advocated for greater use of interactive technologies in museums. Some argued specifically for the importance of play and enjoyment while others suggested a combination of both technology and enjoyment. One group, in particular, highlighted the value of simplicity and usability in appealing to a wider audience. As they progressed with the design workshops, they expressed spontaneous remarks that highlighted feelings of excitement towards the technological interventions that they were ideating: "*This is fun!*"; "*This is better than Pokemon Go!*"; and "*For sure I would go to the museum just to try something different like this*". Finally, as a means of understanding whether participants enjoyed designing their ideal experiences in museums in a design workshop, they were invited to describe the activity on a piece of paper, which would remain anonymous. Adjectives such as *interesting*, *collaborative*, and *innovative* revealed an overall positive assessment of the experience. More information about this evaluation was published here (Cesário, Coelho, & Nisi, 2019b).

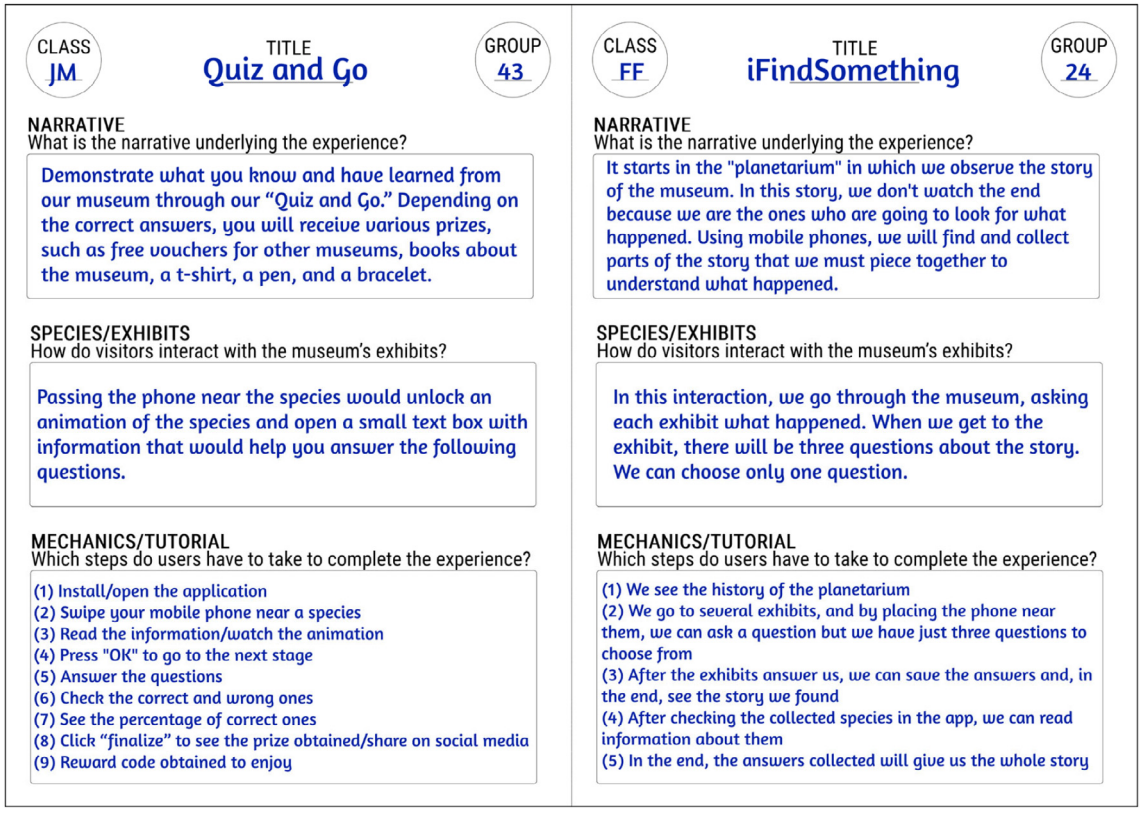

Fig. 3. Translated examples of what two groups wrote in the Concept Sheet. The idea from Group #43 falls into the subtheme *Challenge* and the idea from Group #24 falls into the subtheme *Collection*.

3.3. Thematic analysis

All the data was brought together to identify the themes regarding participants' perceptions of enjoyable mobile museum tours. We used thematic analysis to report the data gathered from the *Concept Sheets*. This technique is used for identifying, analysing, and reporting patterns within data. It organizes and describes the data set in detail (Braun & Clarke, 2006). NVivo 11 was used to organize the analysis. The following steps were taken:

Familiarizing ourselves with the data: A detailed analysis of the *Concept Sheets* was conducted to extract the ideas of the groups. Each working sheet was transcribed and read by the researcher who conducted the sessions. Then, for each sheet, the researcher created a summary regarding which features the museum experience should have, for purposes of discussion with the second author.

Generating initial codes: Through informal discussions between both research authors about the *Concept Sheets*, the decision was made to follow a top-down approach driven by the review of prior literature to sort the concepts into two main themes, such as *game mechanics* and *narratives*. Then, for each of these two themes, each of the *Concept Sheets* (one per group, 46 in total) was grouped into preliminary codes (see Table 2). Though probing question #1 is intended to prompt participants to write about the narrative, and question #3 is intended to prompt participants to write the mechanics to perform the experience, these were not aligned on purpose with the two overarching themes of narrative and game mechanics. These were intended for participants to better communicate about how the experience from question #1 and the link to exhibits from question #2 would be carried out in the museum as a matter of steps to perform the experience.

Searching for and reviewing themes: Codes from the *Concept Sheets* were sorted according to overarching subthemes. The relation between codes and subthemes was double-checked by both research authors to guarantee the same meaning, and clear names and definitions were given to capture the essence of each one. A thematic map with codes and themes was generated from this step (Fig. 3).

4. Results

This section details the thematic analysis of the mobile museum concepts gathered. Please be aware that these results are not definitive; they are formative and focused on this case study based on initial design sessions with 155 teenagers.

4.1. Game mechanics

All groups made use of some game element in their concepts (check Fig. 3 for examples of participants' ideas) but these elements were not a requirement for the design activity. Each of the 46 *Concept Sheets* was coded into the game *mechanics* theme, where we could check which mechanics emerged during the concept generation phase of the process. In this theme, we recorded 8 different codes, which were then grouped into 6 subthemes. The description of each code and the number of times it appeared among the 46 groups can be found in Table 2. Below we describe the subthemes under the theme "game mechanics": (i) clues, (ii) treasure hunt, (iii) challenge, (iv) collection, (v) simulation, and (vi) timeout strategy. These game mechanics were defined

Table 2
Thematic analysis with the summary of the Concept Sheets.

THEME	SUBTHEME	CODES	DESCRIPTION	TOTAL
Game mechanics	Clues	Clues & riddles	Solve riddles/enigmas to go further in the experience. The resolution of the riddle will prompt the visitor to go to another specific exhibit and receive information about it and another riddle, and so on.	4
Game mechanics	Clues	Clues & quiz	Visitors are given clues to find specific exhibits and then to answer a quiz.	4
Game mechanics	Clues	Clues as shadows	Visitors are given a shadow of a specific exhibit as a clue, and they must go through the museum to discover which exhibit that shadow belongs to.	4
Game mechanics	Treasure Hunt	Catch & discover	Search for and discover exhibits in the museum premises and provide information about them.	11
Game mechanics	Challenge	Quiz	A quiz or mini-game about the exhibits in which visitors get points for the right answers and consequently some kind of reward.	11
Game mechanics	Collection	Puzzle	Challenge the visitors to unlock/discover the fundamental pieces to complete the puzzle/collection and understand the puzzle as a whole.	7
Game mechanics	Simulation	Control a marine species	The visitor plays the role of a marine species in the museum. When visitors tour the museum, they do so through the eyes of a specific species of the museum.	4
Game mechanics	Timeout Strategy	Timer	There is a limit of five lives and a one-hour time limit to complete the game tour. At the end of 12 min, one loses one life.	1
Narratives	Adventure	Pirate	(i) The visitor is a pirate who steals exhibits with the goal of attaining a treasure; this treasure varies according to the quantity and rarity of the exhibits. (ii) The visitor is a relic hunter with a special scanner that allows him/her to find hidden treasures disseminated on the museum's premises.	2
Narratives	Adventure	Explorer	The explorer must find the location of a secret message. The visitor must get in touch with several ecosystems and will accompany the explorer in his search.	2
Narratives	Adventure	Chronologic trip	This is a chronological journey through a set of tracks in which the goal is to see who is the first to complete the trip. The visitor has the option of creating an album with photos of the exhibits. Visitors can choose different routes depending on the category of the exhibits (marine and mammal species, geological, and reptiles).	1
Narratives	Adventure	Fisherman	The visitor can fish for the marine species through augmented reality. When the visitor makes the gesture of fishing (with the smartphone), a clue appears, providing the location of the species that needs to be fished. When the visitor finds it, they must launch the fishing rod. The species appears on the screen in its natural habitat, where it is possible to interact with it.	1
Narratives	Emotion	Helping friends	(i) One of the museum's dangerous marine species came to life and ran away, and only the visitors can find it. Throughout the tour, the visitors will receive advice from various exhibits that will help them complete their mission. (ii) The turtle is in a plastic bag, and the visitors must save her. To save her, they must ask for help from the crab, which will help the turtle with its tweezers. Each marine species is necessary to save some other species, and so on.	2
Narratives	Emotion	Aquarium	There is a virtual aquarium where visitors can create and take care of the marine species that are in the museum or endemic in the region.	1

from the data gathered on the working sheets filled out by the participants, and not from previous research.

Clues. This subtheme encompasses the following codes described in Table 2: *clues & riddle*, *clues & quiz*, *clues as shadows*. Twelve groups out of 46 (a total of 44 teenagers out of 155) made use of clues in their ideas. Museum experience designers may combine clues with puzzles: prompt visitors to solve riddles to go further in the experiences, the resolution of the riddle will prompt visitors to go to another specific exhibit, receive information about it, and get an indication as to which exhibit they should visit next. Puzzles involve unlocking pieces of information to understand a whole issue. Museum experience designers can also combine clues with questionnaires, where knowledge is put to the test. Visitors are given clues to find specific exhibits and then are required to answer questions about those exhibits. Usually, these questions are about something visible on the exhibit, prompting visitors to look at the exhibit and not only at the screen of the mobile device. Although eight of the groups referred to clues appearing in text format, the other four groups referred to them appearing as images (image clues: clues as shadows). In this case, the marine species' shadows would function as clues to unlocking information as to where visitors had to go in the museum to discover the exhibit to which that shadow belonged. Some of the exhibits in the museum would have to be marked, as it is unthinkable that any visitor could see all the hundreds of exhibits a museum has to offer and find the corresponding exhibit. Museum experience designers could exploit this strategy to model episodic visits to the museum, with the exploration being diluted through different visits and efforts to find the correct clues.

Treasure Hunt. This subtheme encompasses the code *catch & discover* (Table 2). The participants considered the search for and discovery of exhibits in the design of the museum experience. Eleven groups out of 46 (a total of 37 teenagers out of 155) included treasure hunt elements in the design of their favourite

experience at the museum. The treasure hunt is rooted in the tradition of rescuing something of value, relying on the desire for adventure and effortless wealth. Often, science and entertainment are combined to rescue the past. The treasure hunt determines the experience state, leads to rewards, and represents achievements: Visitors are required to choose, on the device, an exhibit to search; then, when they discover it in the museum, they obtain information about it. Museum experience designers must be careful when combining treasure hunts with clues and a payback feature to wrap up and conclude the experience. Although having a payback at the end of the experience was popular among the participants (check Fig. 3, group #43), this does not necessarily imply that it was essential.

Challenge. This subtheme encompasses the code *quiz* (Table 2). Within this category, 11 groups out of 46 (a total of 36 teenagers out of 155) made use of quizzes in the design of their ideal mobile museum tour: a quiz or a mini-game about the exhibits in which visitors get points for the right answers and consequently some kind of reward. This technique is not novel. Quizzes are carried out in some museums with the teacher's support within a formal education framework. Students go on a school field trip and are invited to explore the museum and see specific exhibits (that they are studying). In the end, they must take a quiz about what they have seen or learned. This type of gaming technique is a way to test the knowledge that students acquired in the museum visit. To our surprise, quizzes emerged as a popular trend during the design workshop. We are unsure if this result was due to the participants' authentic pleasure in being quizzed and showcasing their knowledge, or instead, was due to participants' knowledge that quizzes are a technique widely used after a school field trip. This feature of the experience is meant to entice competition among players, push those who want to be the best to learn scientific facts effectively, and possibly acquire novel information from experience.

Collection. This subtheme encompasses the code *puzzle* (Table 2). The puzzle-solving activity emerged in this study; seven groups out of 46 (24 teenagers out of 155) made use of this technique as a favourite means of exploring the museum. Visitors need to complete a puzzle. They can be provided with the beginning of a piece of information and then must find the other pieces of information to understand the information as a whole. Or, they can be instructed to find a secret message, with each exhibit they find providing them with a note; when all the notes are collected, they will understand the hidden message. As defined, this concept places the collector at a higher level than a simple consumer who intends to buy a product, as it gives the product a higher added value. In addition to purchasing and using/consuming only once, *collecting*, instead, creates a rewarding emotional involvement loop.

Simulation. This subtheme encompasses the code *control a marine species* (Table 2). The feature is intended to illustrate the world from the point of view of one of the marine species or exhibits showcased inside the museum and seeing the exhibition from the eyes of such a species/exhibit. Only 4 groups of the 46 highlighted this feature as an engaging one to spice up the museum visit (a total of 12 participants). For example, visitors can choose a different marine species at different times, and other species would guide the visitor through other places, consequently showing and telling different stories. Each species could have different characteristics. For example, if visitors chose to be a Hammerhead Shark, they would, in the digital context, have 360ºvision; thus, the visit to the museum would be enhanced by 360ºvision. The shark is a big animal that would scare smaller fish, which would hide from visitors who were visiting the museum as a shark. However, if visitors chose to be a smaller fish, one with more limited vision, they could hide from larger fishes but be connected to a different ecosystem altogether. This feature would allow them to understand the museum from a variety of perspectives and gain more knowledge about the specificities of the chosen species. Such a simulation feature can assist museums in creating tours that place the teenage visitor as the centre of the experience, rather than making him or her a passive reader of what the curators have chosen to display on the museum premises.

Timeout Strategy. This subtheme encompasses the code *timer* (Table 2). The feature was used by one group (a total of two participants out of 155). Such an approach consists of visitors having a deadline for completing the museum tour; otherwise, their visit will time out and the story will end or the game will be lost. The idea reported that the visitor would be running away from a digital murder and would have only five lives to play and one hour of gameplay. Every 12 min, a life is lost. This feature makes visitors want to be the best at their tasks. The time factor invites visitors to address what must be addressed as quickly as possible so that they finish their tour without losing the game. However, this may not be an effective method for creating a good experience in museums. It highlights the fact that not everything that comes out of a design workshop is useable, as various stakeholders will have different focuses and desires for a situation for which we design. This might be the case when the clash is too strong: Something that came from teenage participants is not compatible with the values of other stakeholders. This issue is also why all stakeholders should be involved.

4.2. Narratives

Though probing question #1 is intended to prompt participants to describe the experience, 37 out of 46 groups answered this question just by envisioning the experience as a game without any underlined narrative. However, 9 out of 46 groups (a total of 26 participants) were very engaged in thinking narratively, creating adventurous and exciting plots to guide the audience through the museum. We grouped the narratives of these 9 groups into 6 codes that were then grouped into 2 subthemes. The type of narrative plots and the number of times these specific plots appeared among these 9 groups can be verified in Table 2. These scenarios may have a fictitious or simply imaginary basis as long as the focus is not simply on learning more about this story but, rather, mainly on using the exhibits of the museum to unravel more of the story. However, because narratives underlying the experiences were indicated by a relatively small number of participants, there is little information to support the argument that teenagers are indeed interested in these kinds of adventure activities. Below we describe the subthemes under the theme of narratives: (i) adventure and (ii) emotion (check Fig. 4 for examples of participants' ideas).

Adventure. This subtheme encompasses the following codes described in Table 2: *pirate, explorer, chronologic trip, fisherman*. In line with this popular trend, six out of nine groups used adventure as a calling theme in their design (a total of 18 teenagers). Participants demonstrated an interest in being guided through the museum while immersed in a narrative plot. They could take on the role of a nasty pirate who steals exhibits to obtain a treasure at the end: The more valuable the exhibits they steal, the better prize they get. The mobile app can show different levels of valuable exhibits, and these levels are the rooms of the museum: Each room will have various valuable exhibits to steal. Participants would have a given number of exhibits in each room to steal. In another approach, visitors can take on the role of a relic hunter to discover hidden exhibits, which are the keys to

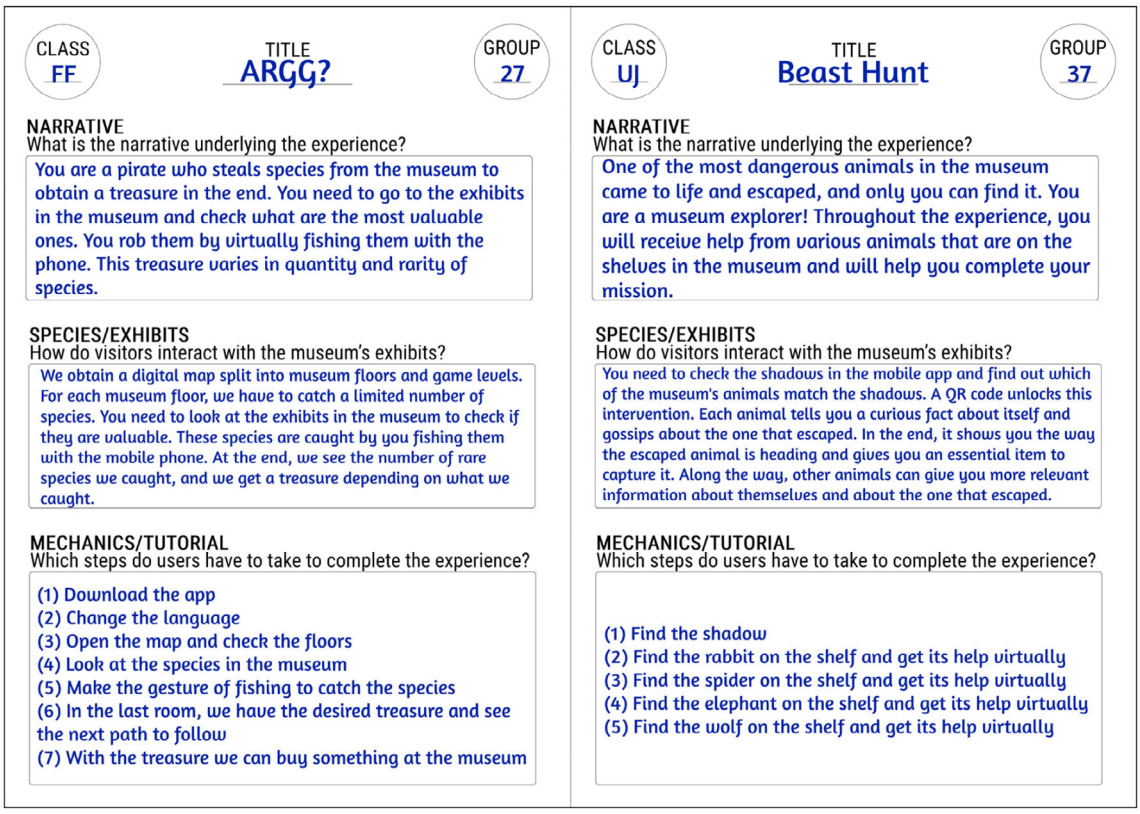

Fig. 4. Translated examples of what two groups wrote in the Concept Sheet. The idea from Group #27 falls into the subtheme *Adventure* and the idea from Group #37 falls into the subtheme *Emotion.*

progressing in the game. The mobile device would analyse the environment and notify the visitor of the secret and valuable exhibits. Participants could take on the role of assisting a well-intentioned explorer walking around the museum randomly to find a secret message to deliver to this explorer. The visitor must contact several ecosystems and accompany the explorer in his search. Each exhibit encountered provides information that helps the participants get closer to discovering this secret message. On the other hand, they could be a visitor who needs to run from a murderer inside the museum and, to do that, must solve challenges throughout the museum premises by encountering different exhibits, which would propose that they solve riddles regarding each exhibit. Participants could also follow a chronologically ordered journey, choosing different routes depending on the category of the exhibits (marine and mammal species, geological, and reptiles). Visitors would have the option of taking a picture of each of those exhibits and creating a photo album with them, accompanied by information about the habitat. Or, participants could take on the role of a simple fisherman who goes fishing for marine species and is caught on an adventurous journey. Through Augmented Reality, they could see a river containing fish. When the visitor engages in fishing, a species appears on the screen in its natural habitat, enabling the visitor to interact with it. Then, the device provides the location of the following species that must be fished.

Emotion. This subtheme encompasses the following codes described in Table 2: *helping friends, aquarium.* Linking an emotional journey within a museum experience is the focus of another storytelling plot used by three groups out of nine (a total of eight teenagers). Participants take on the role of a helper. One of the most dangerous animals in the museum has come to life and fled, and only the visitor can find it. Throughout the museum mobile experience, the visitor receives the help of different exhibits to complete the mission. The other exhibits provide their points of view, an item to use in catching the beast, and information about where it is headed. On the other hand, participants can take on a more passive role through a virtual aquarium where they can create and care for marine animals from the museum, more precisely those endemic to the [region name]. Visitors can interact directly with these species on the mobile device: They can search for them, feed them, and make them grow. Every time they are near a marine species in the museum, they can get a virtual egg, which they can take care of in the mobile application. Museum experience designers can combine this feature with the previous one — adventure. The only difference from the previous feature is that in this feature, emotion, marine species that are part of the story plot must be helped by visitors, and only visitors can make a difference in the species' life. Here, every visitors' choices have an impact on the story. If visitors choose to not help a particular species, the whole experience could be compromised. This feature highlights the value of creating an emotional connection between the visitor and the museum's exhibits.

5. Discussion

Combining teenagers' favourite ways to engage with everyday tasks and cultural heritage spaces allows them to see museums differently, as spaces that could provide engaging and fun experiences. This section reflects on the data collected in relation to our original research question: *Which design recommendations can we generate for teenagers' mobile museum tour guides by exposing their views on enjoyable museum tours?* Although the results presented are common types of activities that teenage participants engage with, the themes and styles merit further investigation. Considering that the participants did not have prior experience in using mobile technologies for interacting with museum exhibitions or even designing gamified tours, such results focus on

this study and, thus, are not definitive and should be reviewed more carefully alongside game designers, curators, and other stakeholders.

The game mechanics from our results resonate with those found in the literature. Clues, treasure hunt, challenge, collection, simulation, and timeout strategies are the mechanics widely used in various types of games, not only for museums but also for general games that anyone can find. The concept of collecting pieces to form a bigger picture, or puzzle, is a widely used technique in gamification (O'Hara, Kindberg, Glancy, et al., 2007). From an early age, children are encouraged to collect various things, from soccer cards to cartoon characters, animals, Legos, cars, etc. However, as a starting point, it is essential to conceptualize what is meant by "collecting". Belk (1995) and Farina, Toledo, and Corrêa (2006) define collectivism as the process of acquiring and possessing things in an active, selective, and passionate way.

From the ice-breaking activity, the teenage participants, without prior knowledge of interactive museums, mentioned "enjoyable" features such as games, interactive content, and social media to empower museums and enhance their visitor experience. Hence, they were motivated to transport their everyday engagement to a mobile idea in a museum, and the mechanics they thought of were no different from what they already knew. As found in the literature, accessing teenagers is quite challenging (Read et al., 2011). There is some catching up to do, as it is difficult to enter; thus, getting to know which engagement techniques might appeal to them is challenging. When teenagers do not find an activity appealing, they are not keen on doing it — and actually, who would be? The problem is that this target group is not often studied for purposes of understanding the best engaging techniques to be used with them, and it is crucial to address their needs (Yarosh et al., 2011). In our work, working with teenagers offered us a plethora of views of their world (Druin, 1998). IDC researchers can exploit, in other contexts, these "enjoyable" features that participants found appealing. For example, infusing game mechanics such as those reported in this work into activities that teenagers usually do not find appealing could be the starting point to engaging them in a given action. We believe that if given an open brief for the design workshops, teenagers – or at least the sample of this study – would fall under the same game mechanics. IDC researchers may need to support their teenage samples in formulating games in museums, as they might have poor knowledge of this subject. Perhaps further development of ideas will require a combination of game designers to assist in further thinking around the game mechanics and development.

Our data indicate that the procedures and rules of a mobile gamified concept (game mechanics) might be important elements for an enjoyable museum mobile tour for the teenage participants of this study, as all groups used some game mechanics in their designs. The entire teenage sample valued (i) the sequence of events unfolding in the game, known as the game narrative (Fullerton, 2008), and (ii) the emotional connections that arose through dramatic elements such as challenges, play, and the premise (Fullerton, 2008). The dramatic elements complement an emotional connection between a user and a game. However, in line with Fullerton (2008), these dramatic elements are complemented by the addition of characters and a story, though in our data, only a few participants thought of characters and a story to be implemented into the game; we found that "adventures" and "emotions" were predominant among the narratives created. A lot has been done and said about adventures in museums, from blockbuster films (*Night at the Museum* and its sequels) to books (Eco's *Foucault's Pendulum* (Eco, 2007) and Brown's *The Da Vinci Code* (Brown, 2009)). In the museum context, emotion echoes the phenomenon of Tamagotchi, a virtual pet that would die unless it was fed and cared for Sherry (2009). This tells us that our sample of teenagers was more engaged in incorporating existing game mechanics into a mobile museum tour than in creating a strong story plot. This result requires further investigation by IDC researchers, possibly by testing mobile museum concepts in situ and understanding (i) firstly, the teenagers' engagement with the mobile and the museum (ii) and, secondly, whether a story plot shifts teenagers' attention away from the museum exhibits and to the game mechanics on the mobile. Still, the game mechanics and narratives presented in the Results section resonate with what the teenage participants might be willing to take on in a museum. Curators and museum designers could start from here in creating engaging museum experiences for this excluded audience group.

From the examples shown in Figs. 3 and 4, these teenagers focused on the game mechanics as well as on the museum content and exhibits, such as by observing the museum's story, asking each exhibit what happened in the plot (Fig. 3, group #24), and checking something about the museum after the visit (Fig. 3, group #43), or even going to each marked exhibit in the museum to check for information needed to pursue the experience (Fig. 4). It is important to note that much competition through game mechanics could switch one's focus from the museum content to the use of the mobile device. We could end up having a tour led by engagement with the mobile device instead of by the exhibits in the museum, as found in Cabrera et al. (2005), Cesário, Radeta et al. (2017), and Nilsson, Blackwell et al. (2016). While competition elements such as challenges can motivate teenagers, they can also cause the teenagers to focus too much on the game mechanics and, therefore, neglect the museum environment. The teenagers will run through the museum in pursuit of the next item, which prevents them from paying attention to the exhibition and can be disruptive to other visitors. Thus, games in a museum should be carefully designed, with time strategies being a critical element. In a past study (Cesário, Radeta et al., 2017), we reported that with a short time limit, young visitors run through the museum to complete a task, without paying attention to the exhibition. We also advised careful crafting of this strategy into the museum visit's logic and purpose (Cesário, Petrelli et al., 2020). It could end up pushing teenagers through the exhibits too quickly and inviting them to finish the tour rather than enjoying it. A possible strategy could be to reverse the time approach, designing so that those at a slower pace win the competition. Puzzles could invite visitors to spend time thinking about and discussing the exhibits to find the solution and should be scored based on the depth of the answer. Other studies found that additional solutions could be to deploy activities leading to calm and reflective interaction (Taxén, Bowers, Hellström, & Tobiasson, 2004) and allow for meaning-making or dialogue (Cesário, Coelho, & Nisi, 2018, 2019a; Ciolfi & Bannon, 2003; Witcomb, 2006). Another alternative is to carefully consider the medium used to portray the message (Parry, 2007) and understand how the interaction could disrupt the user experience, as the fluid nature of digital media can be a disadvantage (Hornecker, 2008).

When our participants thought about the "throw-away interface" to be used for about one or two hours, they guaranteed learning through quizzes and clues. Still, they did not think about having a face-to-face social aspect with their peers at the end or throughout the tour, as seen as a feature in the *Mystery in the Museum* game (Cabrera et al., 2005). With that said, our study cannot conclude that the participants did not like this component, as they were asked to ideate an enjoyable museum experience with a mobile device and were not asked to think beyond the mobile. Thinking about the mechanics of a mobile tour may have caused participants to take on a more unique and non-collaborative role. Further studies are needed to understand whether a digital experience takes away from the human aspects of the tour, thereby discouraging face-to-face collaboration between peers.

Our sample of older teenagers (aged 15–19) is a group that, both historically and currently, has very little power/agency over their lives. There is little literature on designing for and with teenagers (Read et al., 2013; Yip et al., 2012), so any approach that attempts to let their voices be heard is essential, as it can lift the perspectives of this vulnerable group and allow their opinions to be heard and considered. Face-to-face approaches, like the one described in this paper, have the power to facilitate participation and allow HCI researchers to gather the information that best translates the "user's everyday experiences" (Chang & Kaasinen, 2011). Practical and structured hands-on activities can help teenagers be heard and included in designing in and for these spaces.

6. Conclusions

Working with teenagers to design, evaluate, or co-design can give us a comprehensive view of their world (Druin, 1998). We used the data from the design workshops with 155 teenagers to gather feedback and reveal insights into how teenagers believe that mobile interactive technologies could enhance their overall experience at a museum. Furthermore, considering Simon's work (Simon, 2010), these sessions gave our teenage participants a "voice" and engaged them enthusiastically in the design process. This contribution shows that game mechanics ideated by our sample resonate with those found in the literature and should be carefully designed as time strategies comprising a critical element. However, participants were more engaged in incorporating existing game mechanics into a mobile museum tour than in creating a solid story plot and did not consider incorporating a face-to-face social aspect. The *Concept Sheet* specifically encouraged them to craft narratives and mechanics; we do not know what preferences would have been elicited with a different type of prompt. We distil insights into what this specific group of teenagers came up with in this particular design workshop, which obviously might not reflect their desires otherwise. In this work, the design ideas were more popular than other ideas in the sample. However, one cannot infer that most teenagers, in general, are interested in these ideas. Unfortunately, the data cannot speak to that. Teenagers are very familiar with games as a medium. The ideas generated may, thus, reflect their literacy with different forms of engaging media and not what they would prefer or value when presented with options.

While each generation has some shared characteristics based on the world in which they grew up, these are not the same and should not be confused with life-stage differences. The life-stage that humans are in has significant effects on their interests and outlook on life: Teenagers might see the world in a certain way because they are teenagers (have not lived independently, attend school, are not done growing, etc.), and this might be the same as generations before. Given that the insights of this study are broad, they can be generalized or transferable to museum contexts other than natural history. However, this requires further investigation to see if other types of activities are preferred in different contexts. Different contexts might yield different results, and it may be worth repeating similar research as new generations of teenagers emerge.

7. Limitations

We are aware of several shortcomings regarding the described work. The small and biased sample cannot infer what teenagers in general like. We have no idea what teenagers want. We have insights from what an example of 155 teenagers between 15–19 years old came up with in these design workshops to enhance their museum experience, which obviously might not reflect their desires. Hence, the themes and styles merit further investigation, as these results are not definitive.

The design workshop with a mobile experience brief might have participants build on those mechanics and narratives without thinking about the visitor playing a collaborative role. We do not know if giving an open brief to participants would lead them to think differently about collaboration with peers within the museum experience. The *Concept Sheet* looks like an excellent tool to start, but it is quite basic. Participants needed more guidance in creating a narrative. In addition, we did not pilot this method inside the museum; therefore, participants might have found it challenging to imagine and build story plots. Subsequent iterations of this method should guide how to construct a story by providing a backbone through the provision of a clear beginning, middle, and end, and piloted inside the museum.

The sampled teenagers are not from the same background, which can be seen as problematic when considering the results and collected data as one batch. It is a significant limitation that the sessions were not conducted on museum premises, but in closed classrooms, and the participants were given only an oral introduction to the museum. The fact that we did not split the groups by gender and that we had fewer females than males can also be seen as a limitation of this work.

Finally, it is not clear whether participants chose the experiences because they had encountered those experiences somewhere else, or because they had only a short time, or if all members of the groups genuinely agreed that the experiences were interesting activities.

Selection and participation of children

The researcher approached (i) two secondary schools in Madeira Island, (ii) students doing summer internships at our research institute, and (iii) students taking part in a summer camp at the University of Porto. To conduct the studies with teenagers at the schools and at our institute, it was necessary to get approval from the Regional Educational Department in Madeira and an agreement with schools was settled. Regarding the studies at the summer camp, it was necessary to have the approval of the university. Then, written consent was obtained from all of the participants' legal guardians. Participants were informed about data collection process and their participation in the study was completely voluntary. In addition, they were able to withdraw their consent for the data collection at any time without affecting their participation in the activity.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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