Integrating a Location-Based Mobile Game in the Museum Visit: Evaluating Visitors' Behaviour and Learning

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Location-based systems currently represent a suitable solution to enhance cultural experiences inside museums, as they can satisfy visitors' needs through the provision of contextualized contents and services. In this framework, a promising approach to captivate the attention of teenagers—a hard to please target audience—is represented by mobile serious games, such as playful activities aiming to primarily fulfil educational purposes. The use of a mobile digital tool during the visit definitely discloses new opportunities for contextual learning scenarios; however, so far, only a few studies have analysed the impact of different communication approaches on visitors' degree of exploration and acquisition of knowledge. This work aims to enrich this field of research, presenting the conceptual framework; the design principles; and the evaluation results of "Gossip at palace," a location-based mobile game integrating a storytelling approach. The game was developed for an Italian historical residence to communicate its 18th-century history to teenagers, capitalizing on narrative and game mechanics to foster young visitors' motivations to explore the museum and facilitate their meaning-making process. Following a mixed-methods perspective, the article firstly describes to what extent the components of the application were appreciated by teenagers as well as by other visitor segments. Secondly, it provides an insight on the effectiveness of the game in facilitating the acquisition of historical knowledge by participants, enriched by considerations on the methods to be adopted when evaluating mobile learning in informal educational settings. Thirdly, players' degree of use of the digital game throughout the visit is compared to analogous patterns registered for people using a multimedia mobile guide in the same venue. On the one hand, the study pointed out that the game facilitated a wider exploration of the museum; on the other, it highlighted that players mainly gained a superficial knowledge of the proposed contents.

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1. INTRODUCTION

The integration of portable technologies as tools supporting the visit of museums and cultural heritage sites has become very well established in recent years, and different solutions capitalizing on the interactivity of mobile devices have been developed thus far [Boiano et al. 2012; Economou and Meintani 2011]. In this framework, a special role is now performed by location-based systems that rely on sensor technologies to accurately detect the user's position inside a building and accordingly convey suitable cultural contents [Emmanouilidis et al. 2013; Chianese et al. 2013].

These technological advancements have disclosed new educational opportunities for museums, opening up mobile contextual learning scenarios [Brown 2010] in which visitors' behaviours and meaning-making processes are influenced by the use of a portable device and by the ecosystem originated through the mutual interaction involving the user, the device, and the social and physical contexts where the experience takes place [Koole 2009]. The multimediality and interactivity that usually characterize these systems, matched with the ever-growing aptitude towards the use of mobile devices, make portable digital tools a great resource to interest audiences looking for more captivating cultural experiences [Black 2005]. However, developing digital tools that can effectively foster fun and learning still remains a challenge. In this framework, location-based mobile games represent a promising solution [Mortara et al. 2014; Coenen et al. 2013], as they create an edutainment experience that could appeal to visitors while fostering engagement, which is an important precursor of learning [Bitgood 2010; Csikszentmihalyi and Hermanson 1995].

To address these challenges in a real-world application, the location-based mobile game "Gossip at palace" was developed for Palazzo Madama—Museo Civico d'Arte Antica (Turin, Italy). The application can also be defined as a serious game, as it combines entertainment with educational objectives [Mortara 2013; Yusoff et al. 2009; Cosley et al. 2008]. The intended audience for the game is teenagers, a target that may not have either a solid interpretative background or strong intrinsic motivations for extensively appreciating the value of cultural heritage products. Moreover, the current trend of preserving the aesthetic integrity of museum environments limiting the number of the physical learning supports provided (e.g., panels, labels, touchscreens), combined with the use of communication approaches that do not address the needs of specific audiences, do not mitigate the phenomenon: information is thus often hardly accessible—both physically and cognitively—by such an audience. "Gossip at palace" was developed with the goal of filling these gaps: the integration of game mechanics and objectives in the museum visit aimed at fostering teenagers' motivations to explore the palace, whereas the use of interactive digital storytelling was conceived as a way to communicate cultural contents through an accessible and informal style.

This article firstly aims to describe the design and theoretical principles that inspired the architecture of the application, then discuss to what extent different components of the mobile application were felt appealing by users and might ultimately have influenced their visiting experience. Secondly, we explore whether the location-based mobile game actually fostered participants' acquisition of factual knowledge: measuring the achievement of learning outcomes in museum contexts is a much debated issue [Bellotti et al. 2002; Manning and Sims 2004], and our research aims to enrich this field of literature, empirically investigating whether the storytelling approach chosen for our game represents a valuable option to effectively communicate cultural contents. Finally, the article compares the behaviours of the visitors who played the mobile game to those of the visitors who used a mobile multimedia guide developed for the same venue: the aim is to identify how different solutions can affect visitors' exploration and interact with the cultural contents conveyed through the digital tools. This last analysis aims to provide an innovative contribution to the literature, considering that only a few comparative studies of this kind have been published thus far [Chang et al. 2014; Lanir et al. 2013].

The article is structured as follows. Section 2 provides an overview of location-based mobile games and storytelling in museums. Section 3 describes the system design and the game mechanics. Section 4 reports the evaluation of the system, and Section 5 draws some conclusions.

2. RELATED WORKS

Recently, experiments have been conducted on the use of location-based mobile games to enhance young visitors' experiences, as the intrinsic appeal of the media for digital natives and the active role demanded to the players while moving through the physical space usually promote participants' satisfaction [Thian 2012; Mannion 2012; Botturi et al. 2009; Waycott et al. 2005; Schwabe and Göth 2005]. Enjoyment and engagement experienced by participants are highly valued as well by an educational point of view: in fact, they are considered not only as conditions facilitating learning but as learning outcomes in themselves, together with the development of knowledge and understanding, the improvement of skills, and the changes in values and attitudes [Hooper-Greenhill 2007]. A recent survey has pointed out that among the range of digital games developed to foster awareness on cultural heritage, the most common approach is represented by quizzes and puzzles [Mortara et al. 2014], whereas the "adventure" or "action" genres are still a minority. The extensive use of riddles [Ghiani et al. 2009; Cabrera et al. 2005] is well justified in light of task-based learning, a pedagogical theory that stresses the importance of concrete, focused activities to develop knowledge and skills [Bellotti et al. 2012; Willis 1996]. Administering isolated tasks may be a successful option because it also allows easy inclusion of ad hoc joining and leaving mechanisms that enable the users to play with the application as they like. However, the need to experiment with game mechanics that may encourage players' engagement throughout the whole visit and thus expose them to a larger variety of learning stimuli is widely advocated [Mortara et al. 2014; Connolly et al. 2012].

Apart from game mechanics, another way to capture visitors' attention and communicate cultural content is represented by digital storytelling [Lombardo and Damiano 2012; Nack and Waern 2012; Callaway et al. 2012]. The interactivity allowed by digital technologies has pushed forward the narrative potential of storytelling, giving visitors the chance to enrich their experience with multimedia contents and customize the stories according to their own interests. The increase in interactivity has particularly favoured nonlinear storytelling—a particular approach where events are not strictly presented in chronological order but depend on other criteria [Danks et al 2007; Wolff et al. 2012], such as the position of the user in a given environment. The relationship between interactivity and digital storytelling has been further explored by Sharples et al. [2013], who have borrowed from the gaming theory [Zimmerman 2004] the concept of "explicit interactivity" and applied it to mobile digital storytelling: through a combination of human-computer interactions and physical movements around the space, visitors have the opportunity to connect with interactive objects and affect the content of the story as it is being delivered. Then, various types of interactive digital storytelling have been identified by authors: (1) *tree-branching* structure, where the user is presented with the possibility to choose among several possible situations; (2) *braided multilinear* experience, where a core narrative branches into a number of plot directions, which then converge and reintegrate with the core; and (3) *rhizome*, where stories of many visitors are interwoven and narrations depend on paths taken by other people or on the frequency locations have been visited [Sharples et al. 2013]. As underlined by Ioannidis et al. [2013], the main challenges and issues that currently lie in the introduction of a digital storytelling approach in a museum setting concern the three separate aspects that are involved: the museum topology, the museum objects, and the story concepts. As a consequence, the different components of mobile digital storytelling tools need to be carefully balanced to match personalization and engagement with the achievement of behavioural and learning objectives that go beyond pure entertainment [Bellotti et al. 2003]. Whereas at this stage of research a wide number of mobile applications aiming

at enhancing the visitor experience has been presented, there is still a relative lack of publications thoroughly analysing how they can create particular contexts of visits, ultimately influencing visitors' behaviour and learning. For instance, the work of Chang et al. [2014] pointed out that visitors using a mobile application featuring augmented reality functionalities registered a better learning performance if compared to visitors who carried out the tour using an audio guide or without any support. Lanir et al. [2013] have compared the behaviours and circulation paths of the visitors who used a multimedia guide to the patterns registered for people visiting the museum without any support instead, finding that visitors using a mobile guide stayed in the museum longer and spent more time in front of the exhibits when they could get information from the guide.

3. SYSTEM DESIGN AND GAME DESCRIPTION

3.1 Museum Context, Learning Objectives, and Target Audience

Palazzo Madama—Museo Civico d'Arte Antica is a UNESCO-listed World Heritage site and ancient art museum located in Turin, Italy. Especially renowned for its baroque façade, the building still preserves beautiful 18th-century frescoes and an extensive collection of decorative and fine arts displayed on four floors, on a surface of more than 4,000 square meters. Even though the baroque era played a major role in the definition of the history and the art of the building, the interpretative concept of the site primarily focuses on the artworks on display: as a result, the political role played at that time by the royal Savoy family, together with the stories of the people who inhabited the palace, are not perceivable during traditional visits. To fill this communication gap, a location-based mobile application was developed, offering visitors contextual information that could help them discover the characters, traditions, and events that characterized the palace in the 18th century. More specifically, the learning objectives set for the game were as follows: to communicate the story and the personality of Marie Jeanne Baptiste of Savoy-Nemours, the Royal Lady who inhabited the palace in baroque times; to convey information about the history of the Savoy dynasty and some of its members; to make people understand the function of the building in the past; and to explain the meaning of a selection of decorations and objects on display. With regard to the intended audience, the application was primarily conceived for teenagers; the reasons behind this target choice are twofold: firstly, no learning support specifically developed to engage this audience was available in the museum, and secondly, the evaluation of a location-based mobile game previously developed for children visiting the venue pointed out encouraging results in terms of users' engagement and degree of appreciation of the experience [Xhembulla et al. 2014]. The older age of the target induced developers to push forward the number and depth of information communicated through the game: we decided to shift from the quiz-based approach, used for children, to storytelling, a method that was considered more appropriate to convey richer cultural contents.

3.2 System Design

"Gossip at palace" is provided as a location-based mobile game optimized for 7-inch tablets borrowable at the ticket office. Design decisions were made taking into account the context of the particular museum and the goals intended for the mobile experience [Antoniou et al. 2013], together with the literature on game mechanics [Sylvester 2013; Iuppa and Borst 2007] and location-based mobile games for learning [Ardito et al. 2010]. Coherently, it was decided to do the following:

(1) provide a back-story as a basis of the game tasks to provide a meaningfully background to the experience;
(2) exploit role-playing to enhance visitors' emotional engagement;

Fig. 1. Avatar selection.

(3) provide contextual clues linked to specific places to better capitalize on the physical position of the user;
(4) integrate a variety of microgames [Bellotti et al. 2008] challenging different visitors' skills;
(5) integrate rewards tightly with exploration and tasks to enhance visitors' motivation; and
(6) balance two conflicting elements, such as competition and knowledge acquisition, by rewarding the depth and accuracy of exploration rather than short game time completion [Bellotti et al. 2003].

Due to the exclusively on-site nature of the game, recommended previsit activities [Ardito et al. 2010] were not implemented; additionally, the lack of a Wi-Fi connection throughout the museum prevented the arrangement of activities to be shared through social networks.

3.3 Storytelling Approach

The *back-story* is as follows. It's 1717, and the Royal Lady Marie Jeanne Baptiste of Savoy-Nemours—who ruled as regent before the majority of her son—believes that there is a spy in her palace; she thus asks the player to investigate and find who is the betrayer among the characters in the palace. This story links the context-based cultural information to the game tasks. To allow users a quick understanding of the game goals and the actions required to fulfil this challenge, the back-story is presented under the form of a short video in the introductory phase: the first moments of a playing experience are vital to the whole game, as players become familiar with the game structure and rules [Jegers 2007], so the player was provided with the fundamental background information from the beginning of the experience. Before starting the actual adventure, the player selects her avatar among a set of four virtual characters (Figure 1): this choice aims to enhance empathy throughout the game and influences the following phases of the game, customizing dialogues and other information.

After choosing the avatar, the game begins and the user can start her visit. The "interactive dilemma" described by Peinado and Gervas [2004]—that is, the tension between telling visitors where to go or let them freely wander through the venue—was faced opting for a constructivist approach [Hein 1998], thus allowing them to visit the museum following their own paths. This choice was reinforced by considering visitors' preferences: recent empirical research shows that most people follow an exploratory behaviour [Falk 2011], preferring to freely explore the venue even when using a dedicated mobile application [Rubino et al. 2013]. Moreover, studies specifically focusing on the evaluation of mobile games developed for cultural heritage contexts pointed out that players favour visiting the venues quite autonomously, without following a preconceived route [Ghiani et al. 2009; Bellotti et al. 2003].

Fig. 2. Panoramic photo augmented with a virtual character.

The active role of visitors regarded not only their movement through the physical space but also the degree of exploration of the contents: players were given the opportunity to discover the story of the palace from different perspectives and choose to what extent deepening the pieces of information progressively provided.

To accurately identify the position and orientation of the visitor inside the museum and thus convey appropriate contents, an indoor positioning system based on the recognition of visual markers was adopted [Barberis et al. 2014]. When the player scans a marker, a panoramic photo of the room—augmented with one of the 16 virtual characters that animate the game—is shown on the device (Figure 2). This approach was found to be particularly intuitive during our previous studies [Rubino et al. 2013] and was thus integrated in the application to help users easily connect the cultural contents with the physical context of the museum. The use of real-time images rather than preloaded photos was not deemed convenient, as object recognition requires a complex processing and highly depends on a variety of conditions (e.g., light, camera orientation) to be accurate.

To further help visitors focus their attention, facilitate their orientation process, and minimize the mental effort required to make sense of the contents provided, our system was set up to automatically rotate the panoramic photo towards the point of interest described by the virtual character.

The identity of the virtual characters is defined by different genders (masculine, feminine), social status (noble, servant), and personal inclinations (attitudes, abilities, preferences, etc.): virtual characters aim to synthetically present historical data, suggesting the atmosphere of that epoch and providing teenagers with textual and visual elements that could help them better relate to that historical period. The connection of each virtual character with the room in which the user is located can either be obvious or not without interacting with the character: Palazzo Madama has undergone several transformations during the centuries, and the role of the virtual characters allows perception not only of 18th-century stories but also the functions of the different rooms of the palace at that time (e.g., the kitchens were located in the space that is now used as a storage room). By interacting with the virtual characters, players are exposed to written dialogues (Figure 3): following their interests, players can select different branches of information and build their favourite microstories. A finite state machine governs the creation of dialogues, proposing different sentences to choose from, according to what the user has previously chosen and attributes points according to the extent the user has followed the conversation flow.

While designing the dialogue structure, important nodes were identified: overall, the storytelling adopted approach can be defined as a braided multilinear experience, as the core narrative of each

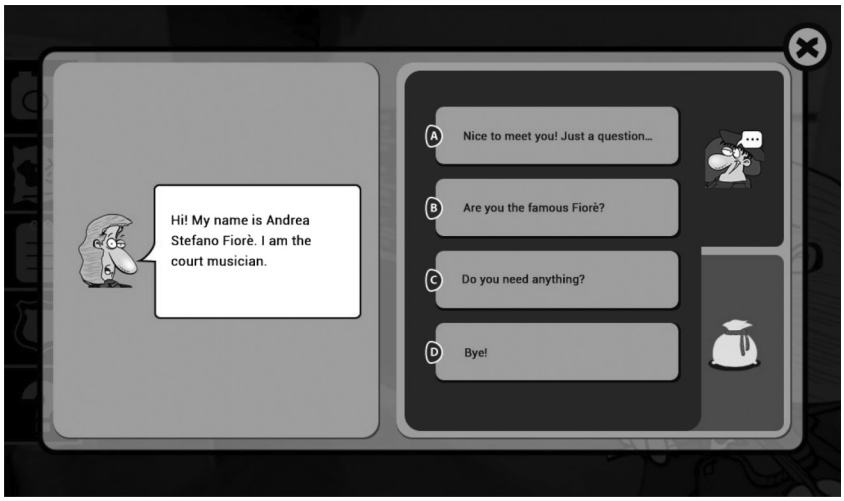


Fig. 3. Example of a dialogue.

dialogue branches into several directions [Sharples et al. 2013]. The binding agent between all dialogues was represented by the aim of the game—finding the spy. The branching of the narrative was conceived at its microlevel—that is, the single dialogues appearing when scanning the marker in a museum room. Since the number of rooms in the museum is much larger than the number of characters and each visitor is free to visit a room many times, each character can be met several times in different places. Therefore, the system was set up to keep record of the branches of dialogues selected by the player and thus guarantee the continuity of the experience.

3.4 Game Mechanics

To get the clues necessary to successfully complete the game, players need to earn points and achieve new levels. Coherently with the objectives set for the experience (i.e., encouraging the discovery of the building and promoting in-depth exploration of the cultural contents), two categories of scores were created:

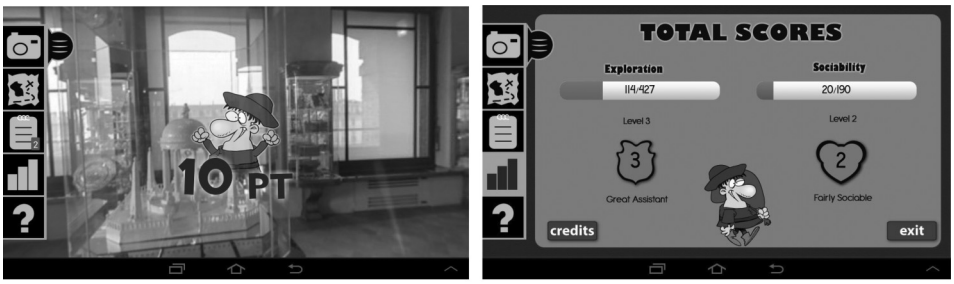
—*Exploration score*: This score depends on the user's movements throughout the building. To progress, the player is invited to explore the physical space and scan as many visual markers as she can.

—*Sociability score*: This score is based on the user's interaction with the virtual characters. Players can earn points by getting involved in the virtual conversation and answering appropriately to the depicted situation, as well as taking into account the role of the selected avatar.

To add variety to the experience and increase the appeal of the game to hard-core players, virtual objects are scattered on the panoramic photos: users can earn additional sociability points by first collecting and then giving the appropriate objects to the virtual characters.

A variety of microgames proposing observation, reasoning, and arcade tasks [Bellotti et al. 2008] was also included in the game to encourage visitors' focus on the physical environment of the palace and enhance the momentary satisfaction stemming from the successful completion of activities. Solving quizzes, puzzles, crosswords, missing details, and memory activities are awarded with extra points, favouring a faster progression in the game.

To progressively reward players and foster their motivation, every time the player accomplishes a meaningful action, a triumphant version of the avatar appears, reporting the amount of points just



(a) (b)

Fig. 4. Score categories (a) and triumphant character (b).

earned (Figure 4(a)). Additionally, users can constantly check their advancements by browsing a dedicated section of the application showing the present score status (Figure 4(b)); the degree of advancement is also expressed through badges and adjectives that describe the level achieved (e.g., "Great Assistant," "Fairly Sociable"), with the aim being to enhance the player's emotional engagement with her virtual counterpart. As the player progressively explores the venue and interacts with the virtual inhabitants of the palace, she receives a clue that is useful to exclude a character among the set of suspects. To allow visitors to play with the game repeatedly without compromising the tension linked to the discovery of the spy, the betrayer is recalculated by the game engine at every match.

4. EVALUATION OF THE GAMING EXPERIENCE: METHODS, RESULTS, AND DISCUSSION

To understand how the location-based mobile game influenced visitors' behaviours and investigate whether it was effective in fostering enjoyment and learning, different methods of evaluation were selected by researchers and then performed by real users. More precisely, the objectives of the study were as follows: (1) to understand the degree of appreciation and acceptance manifested by users towards the gaming approach proposed and towards specific components of the application, (2) to test the effectiveness of situated digital storytelling for the acquisition of factual knowledge, and (3) to investigate to what extent the game influenced players' behaviours in terms of physical exploration of the museum.

4.1 Investigating Visitors' Perceptions and Learning: Questionnaires and Semistructured Interviews

To answer to the first two research questions, the game experience was evaluated through a field study entailing the participation of actual visitors of the museum, combining a short questionnaire with semistructured interviews. Overall, 37 volunteers were recruited at the museum ticket desk, asking them to freely use the "Gossip at palace" application. All volunteers were first-time visitors of Palazzo Madama—Museo Civico d'Arte Antica, and the panel was composed of 54.1% males ($n = 20$) and 45.9% females ($n = 17$), with ages spanning from 7 to 55 years. When recruiting the volunteers, it was decided to engage teenagers—the intended target audience of the game—as well as children and older visitors to test whether the use of the followed gaming approach could be extended also to other age groups.

4.1.1 Questionnaires: Results. The questionnaire (Figure 5) was designed considering both the mobile nature of the experience [Baharuddin et al. 2013; Gansemer et al. 2008] and the educational scope of the application [Donker 2005]. The questionnaire included 10 questions that aimed to evaluate some aspects of the usability of the game (Q1, Q2), the satisfaction manifested by users (Q3, Q4, Q5, Q6), and the appeal of the game mechanics implemented (Q7, Q8, Q9, Q10). Visitors were allowed to express

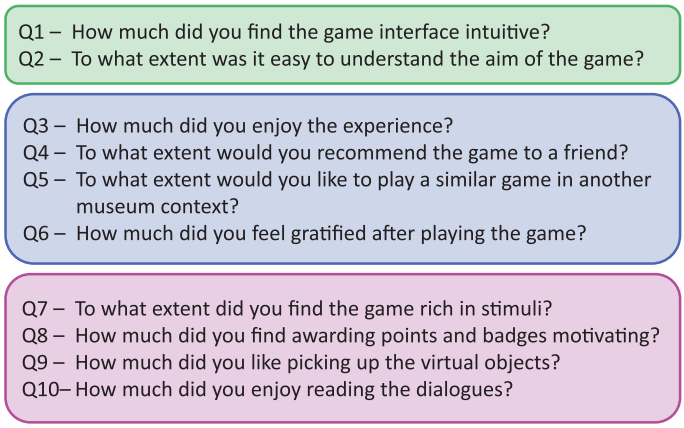


Fig. 5. Questionnaire used for the evaluation of the game.

their opinions on a seven-point scale (min. 1, max. 7). The mean value registered for the intuitiveness of the game interface was 5.41/7 (SD = 1.462; Mdn = 6; Q1), whereas understanding the aim of the game (i.e., finding the spy among a set of characters) was considered easier (M = 5.92, SD = 1.320; Mdn = 6; Q2). The variety of stimuli provided by the game was rated 5.30/7 (SD = 1.412; Mdn = 5; Q7); more specifically, the game mechanic that was appreciated the most was gaining points and badges while progressively interacting with the game (M = 5.78, SD = 1.493; Mdn = 6; Q8), followed by the possibility to discover cultural contents through the different branches of the dialogues (M = 5.59, SD = 1.279; Mdn = 6; Q10); picking up virtual objects received a lower degree of appreciation (M = 5.11, SD = 1.577; Mdn = 5; Q9). These results confirm the importance of integrating game mechanics, such as points and badges, that leverage on players' motivation and relate the experience with a sense of personal reward. Additionally, it must be noted that an exclusively virtual activity, such as picking up virtual objects, was not so much appreciated. This suggests that including tasks that entail an interaction with the real environment is a more appropriate approach for location-based mobile games, since players want to take the most of their presence in the venue.

The higher appreciation towards the written dialogues was somewhat unexpected: in fact, exploring the different branches of contents entails reading, which is a distracting and energy-demanding activity and thus not usually very much appreciated by visitors in museum contexts. The semistructured interviews indicate that the degree of interaction and personalization allowed by the dialogues contributed to making visitors appreciate an attention-consuming activity.

The positive attitude toward the game was reinforced by the answers referring to the overall enjoyment of the gaming experience (M = 5.68, SD = 1.41; Mdn = 6; Q3), the personal gratification felt by visitors (M = 5.11, SD = 1.65; Mdn = 5; Q6), the recommendation of the game to a friend (M = 5.22, SD = 1.58; Mdn = 5; Q4), and the willingness to play a similar game in another museum context (M = 5.11, SD = 1.58; Mdn = 5; Q9). Even though the reported values are quite akin, the results suggest that visitors generally had a positive opinion towards the mobile serious game approach, even if they identified some limits in the tested application, which emerged through the semistructured interviews.

To understand whether the results varied in relation to participants' age groups, we separately analysed children, teenagers, young adults, and adults' responses. Table I and Figure 6 highlight that children manifested the highest levels of personal satisfaction (Mdn = 6.50; Q6) and enjoyment of the overall experience (Mdn = 7.00; Q3); similar results were registered with regard to the

Table I. Questionnaire: Participants' Responses by Age Group

	Children			Teenagers			Young Adults			Adults		
	M	SD	Mdn	M	SD	Mdn	M	SD	Mdn	M	SD	Mdn
Q1	5.7	1.418	6.0	5.4	1.302	5.5	5.2	1.856	6.0	5.3	1.418	5.0
Q2	5.9	1.287	6.0	6.3	1.035	6.5	6.0	1.500	7.0	5.6	1.506	6.0
Q3	6.6	1.265	7.0	5.6	1.302	6.0	5.3	1.225	6.0	5.1	1.524	4.5
Q4	6.5	0.972	7.0	5.3	1.035	5.0	4.7	1.732	5.0	4.4	1.647	4.0
Q5	6.0	1.687	7.0	5.6	1.685	6.0	4.8	1.716	5.0	4.0	2.261	4.0
Q6	5.8	1.687	6.5	5.4	1.061	5.5	5.0	1.658	5.0	4.3	1.829	4.0
Q7	6.2	1.229	7.0	4.8	1.389	5.0	5.6	0.882	6.0	4.6	1.578	4.0
Q8	6.4	0.843	7.0	6.0	1.195	6.5	5.8	1.302	6.0	5.0	2.108	5.5
Q9	5.6	1.265	5.5	5.6	1.188	6.0	4.7	1.803	5.0	4.6	1.838	4.5
Q10	5.5	1.509	5.5	5.9	0.991	6.0	5.4	1.424	5.0	5.6	1.265	6.0

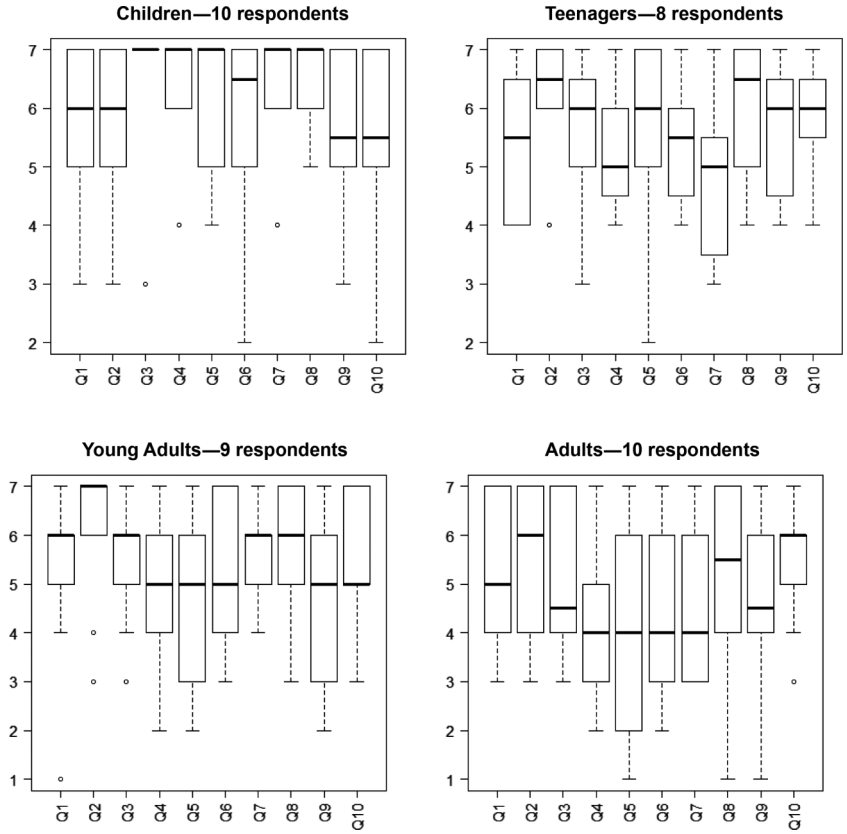


Fig. 6. Box plots: distribution of participants' answers by age group. The bold line indicates the median value.

recommendation of the game to a friend (Mdn = 7.00; Q4), the desire to play a similar game in another museum context (Mdn = 7.00; Q5), the variety of stimuli provided by the game (Mdn = 7.00; Q7), and the appreciation of points and badges (Mdn = 7.00; Q8). Overall, dialogues were appreciated by all age groups and especially by adults (Mdn = 6.00; Q10).

Understanding the aim of the game was particularly easy for young adults (Mdn = 7.00; Q2) and teenagers (Mdn = 6.50), whereas it was found more difficult by adults (Mdn = 6.00) and children (Mdn = 6.00). In particular, the use of the game interface was not found to be very intuitive by adults (Mdn = 5.00; Q1).

Linear regression analysis better explained these phenomena, pointing out that there is a significant inverse relationship between the answers registered for Q3 ($r = -.427$, $p = 0.008$), Q4 ($r = -.474$, $p = 0.003$), Q5 ($r = -.496$, $p = 0.002$), Q6 ($r = -.451$, $p = 0.005$), and Q8 ($r = -.459$, $p = 0.004$) and the participants' age. Additionally, the Kruskal-Wallis test with a post hoc Dunn's test highlighted that for Q3 and Q4, there is a significant difference in the comparison between children versus young adults' responses ($p = 0.046$ and $p = 0.041$, respectively) and children versus adults' responses ($p = 0.041$ and $p = 0.008$, respectively); a similar tendency was registered for Q7 (children vs. adults, $p = 0.05$).

These results made it evident that despite the complex cultural contents that were conveyed through the game, "Gossip at palace" was found enjoyable by children as well, a segment that was not originally included among the target audience intended for the game. The data highlighted that the game did not meet adults' preferences, suggesting that such an approach could not be appropriate for this audience, who finds that interacting with a digital interface is a difficult and time-/attention-consuming task.

4.1.2 *Semistructured Interviews.* The semistructured interviews conducted with the volunteers mainly were aimed at (1) better identifying strengths and weaknesses of the application and (2) detecting whether the location-based mobile game facilitated the visitors' learning process.

With reference to point (1), the elements that participants appreciated the most were the richness and variety of the cultural information provided, together with the role of the virtual characters, which helped visitors focus their attention on objects and decorations that they would have otherwise not noticed. The conversational tone of the dialogues, matched with a synchronized movement of the panoramic photo of the room towards the point of interest, functioned as a trigger to catch players' attention and provide contextualized information. The presence of microgames contributed to an enjoyable experience as well, diversifying the tasks requested to the players. The cartoonish interface of the application represented an asset to engage children and teenagers, who got really excited when seeing the virtual characters and objects. On the contrary, the graphics were not felt as particularly appealing by adults and some young adults, who considered them too childish. Interviews confirmed the important role played by levels, points, and badges in motivating players, and a successful/unsuccessful completion of the game contributed to participants' level of satisfaction: *Playing the game was fun, and I'm so happy I've found the spy!* (24-year-old woman); *The game was nice, but then I got annoyed because I could not finish it* (9-year-old girl).

Even if participants generally valued both the cultural information provided and the possibility to select their favourite branches of dialogues, it must be noted that users frequently mentioned experiencing "fatigue" after playing the game for more than 1 hour: this phenomenon led some of them to quit the game before finding the spy, adding to exertion a feeling of frustration emerging from not having completed the game. Volunteers did appreciate the freedom of exploration allowed by the game, but they found it too long, and the exposition to excessive information induced cognitive overload: *I used the game to explore the first two floors of the palace, but then I gave up: I think it was a bit tiring* (31-year-old man); *We explored the whole palace because we wanted to get the clues and win the game, but at the end we were very tired. The dialogues are very interesting, but at some point we started to skip them fast, without reading them: we were tired, and we just wanted to gain clues and points to win the game* (24-year-old woman). Additionally, some young adults and adults explained that they would have preferred more information on a larger number of objects on display, suggesting that mobile applications should provide users with a great variety of stimuli to satisfy their needs. These reports

Table II. Grid Used to Evaluate Each Answer

Conditions	Score
Participants did not answer or reported wrong information	0
Participants gave an inappropriate answer, but the information was correct	1
Participants gave a correct answer, specifying one detail	2
Participants gave a correct answer, specifying two or more details	3

induced the conclusion that the structure of the game was generally appreciated by players but that the system of clue provision needs to be better calibrated to reduce the duration of the game play to about 1 hour while keeping the free-exploration setting. Other enhancements could be represented by the reinforcement of the main narrative and by an increase in the variety of activities provided. Creating favourable conditions for the successful completion of the game would also increase the levels of satisfaction of players, and it cannot be excluded that this could encourage them to play again, since the randomness inside the game makes each match different, while exploring other areas of the palace. Adults and young adults' comments confirm, as expected, that during the visit people generally want to satisfy their personal curiosity, having the chance to freely access the contents related to a variety of objects, whereas they are less inclined to deepen their knowledge about stories that are connected to a limited number of items.

Finally, interviews pointed out that whereas children and teenagers found the game suitable for their age, young adults and especially adults recommended the game for visitors up to 15 years of age; some participants declared that they would envision the use of the game for school groups particularly interested in the 18th century as an enjoyable way to explore the history of the palace during that period.

To check the achievement of the learning outcomes described previously, participants were asked to answer four questions during the interview. This task aimed to investigate whether they could recall some historical information conveyed through the game. Given that "Gossip at palace" mainly aimed to communicate historical contents that are not presented in the museum through traditional interpretive materials, it was not deemed appropriate to ask the same questions to nonplayers to understand whether the game was more effective than panels and labels in communicating cultural information. The questions were open ended and formulated not to require a unique answer (e.g., *What can you tell me about Victor Amadeus II?*), as it was not known which branches of dialogues had been actually followed by the users. Additionally, this choice was made to not intimidate the participants and make them not feel judged. Despite these measures, 5 of the 37 participants refused to answer. If it can be supposed that in these cases visitors did not feel confident about the acquisition of new knowledge and that the game probably did not foster this kind of learning, these data also induce a methodological reflection driving towards the necessity of elaborating and integrating new methods to evaluate the results of informal learning environments. Even though previsits tests were not conducted, participants' answers were considered as a sign of new knowledge acquired thanks to the mobile game for a variety of reasons. First of all, the traditional interpretive materials available in the museum do not provide hints about the stories of the people who inhabited the palace during the baroque era. As well, the local history of the period is not usually taught in schools and is not widely known. Finally, participants were all first-time visitors and did not have the chance to attend visits led by a museum guide or other educational initiatives. To evaluate the degree of knowledge acquisition, each answer was thus assigned a score, as shown in Table II. Then, the total score was calculated for each participant, and performances were coded as reported in Table III. Answers were examined by two researchers, with an interrater agreement of 97%.

Table III. Classifying Participants' Acquisition of Historical Knowledge: Categories

Total Scores Appointed to Participants	Acquisition of Factual Knowledge: Categories
0–1	L0: Participant did not show any acquisition of historical knowledge
2–5	L1: Participant manifested a sporadic acquisition of historical knowledge
6–9	L2: Participant manifested the acquisition of diffuse but basic historical knowledge
10–12	L3: Participant manifested the acquisition of diffuse and detailed historical knowledge

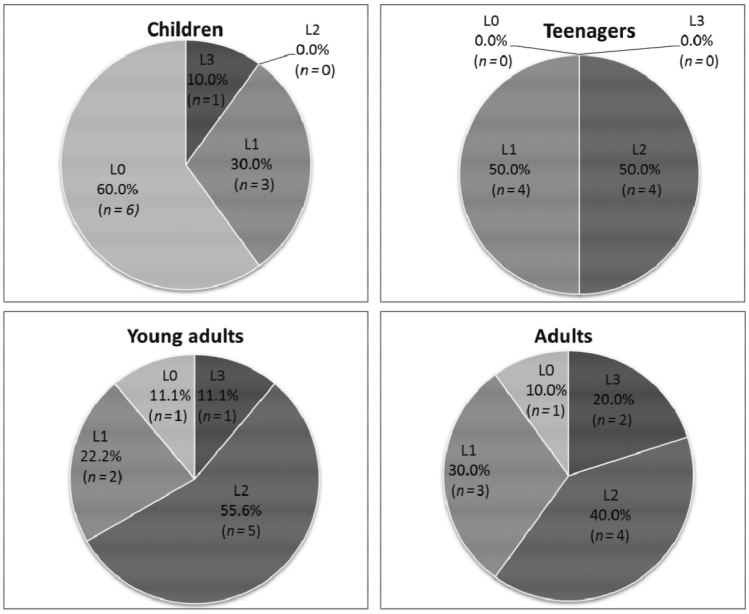


Fig. 7. Participants' acquisition of factual knowledge by age group.

Overall, 21.6% ($n = 8$) of the participants did not show any acquisition of historical knowledge (L0), whereas 10.8% ($n = 4$) manifested the acquisition of diffuse and detailed historical knowledge (L3); L1 and L2 represented 32.4% ($n = 12$) and 35.1% ($n = 13$), respectively. These results indicate that there is evidence that the game was effective in conveying key contents (e.g., the political role of the Royal Lady and of her son, the function of the building in the 18th century), at least for a certain number of players. The fact that some respondents were able to recall more detailed information indicates that some players meaningfully explored the "deep branches" of the dialogues as well.

The analysis of participants' answers according to age groups (Figure 7) highlighted that the majority of children did not show any evidence of learning, teenagers generally acquired sporadic and basic historical knowledge, and young adults mainly manifested diffused basic learning, whereas adults' performances were more variable, nevertheless registering the highest percentages of detailed historical knowledge. Linear regression analysis pointed out that there is not a strong relationship between participants' age and their learning level ($r = 0.357$; $p = 0.30$).

In conclusion, it can be stated that a dichotomy between the appeal of the gaming approach and its effectiveness in communicating cultural contents exists: on the one hand, the gaming activity was more appreciated by children and other young visitors, but it was only partially effective in fostering

the acquisition of factual knowledge; on the other hand, the older visitors were less engaged by the game itself, but they were able to process and recall more detailed information.

Interestingly, during the semistructured interviews, a different and possibly more adequate evaluation methodology emerged. Some children reacted positively when invited to freely comment on a picture of a room in the palace: in fact, they were able to make a detailed description of the ceiling decoration, also explaining the function of the room in the 18th century: *Oh, this is the room where I met the [virtual] musician: the ceiling was decorated with children performing different games in the open air* (10-year-old boy). Given that this piece of information is not available elsewhere in the museum and that they were first-time visitors, it can be stated that the game was effective in communicating cultural contents to young boys and that this method was more appropriate to investigate learning in an informal educational setting. The method was then successfully proposed to other participants. The descriptions made by volunteers when exposed to the pictures of the rooms included a variety of information: the simple identification of the name of the rooms, their spatial (near, opposite, etc.) or functional (bedroom, ballroom, etc.) identification, the recall of the virtual characters met (guard, gentleman, etc.), the microgames/activities performed (puzzles, crosswords, etc.), and the descriptions of the physical characteristics and the meaning of the decorations and the objects on display. These data highlight that the combination of different stimuli provided by the game (physical environment, virtual characters, microgames, cultural contents, etc.) was effective in stimulating different visitors' memory skills, resulting in a higher probability of fostering some kind of recall and learning.

4.2 Investigating Visitors' Behaviours

To answer to the third research question, which is to investigate to what extent the game influenced players' behaviours in terms of physical exploration, the data log automatically collected by the system of 55 players was analysed. The parameters that were taken into account were the number of markers scanned by the users and the amount of time spent by players using the application. The analysis of the first parameter was considered as an indicator of the ability of the application to motivate players towards the progression of the game and the exploration of the palace; the second parameter was registered to understand the time length usually spent by users playing.

The analysis pointed out that on average, players scanned 57.4% of the markers deployed in the museum (Min = 22%, Max = 100%; SD = 27%). The average amount of time spent playing was 75 minutes (Min = 30 minutes, Max = 165 minutes), with a standard deviation of about 38 minutes. These results show that players usually scanned more than half of the markers, indicating that the application was effective in fostering players' desire for exploring the palace and actively interacting with the content. To understand the influence of the application on visitors' behaviours, they were compared with data collected from "Step by Step," a mobile multimedia guide available in Palazzo Madama—Museo Civico d'Arte Antica and based on the same vision-based system used in the serious game. This application allows the user to explore the museum collections and access relevant cultural contents according to her position in the building. When the user scans one of the markers deployed in the environment, a panoramic photo of the room is visualized. The photo is augmented with hot spots in correspondence to the main works of art or elements of the room itself (e.g., ceiling). These hot spots allow the user to access contextual information provided in the form of texts and pictures [Rubino 2013; Rubino et al. 2013].

The compared analysis of the data log highlighted that 63 users of "Step by Step" scanned the markers with a mean rate of 35.75% (SD = 17.31%): this result clearly shows that the game was more effective than the traditional application in fostering visitors' will to explore the palace. The average time spent in the museum was 97 minutes, with a standard deviation of 62 minutes.

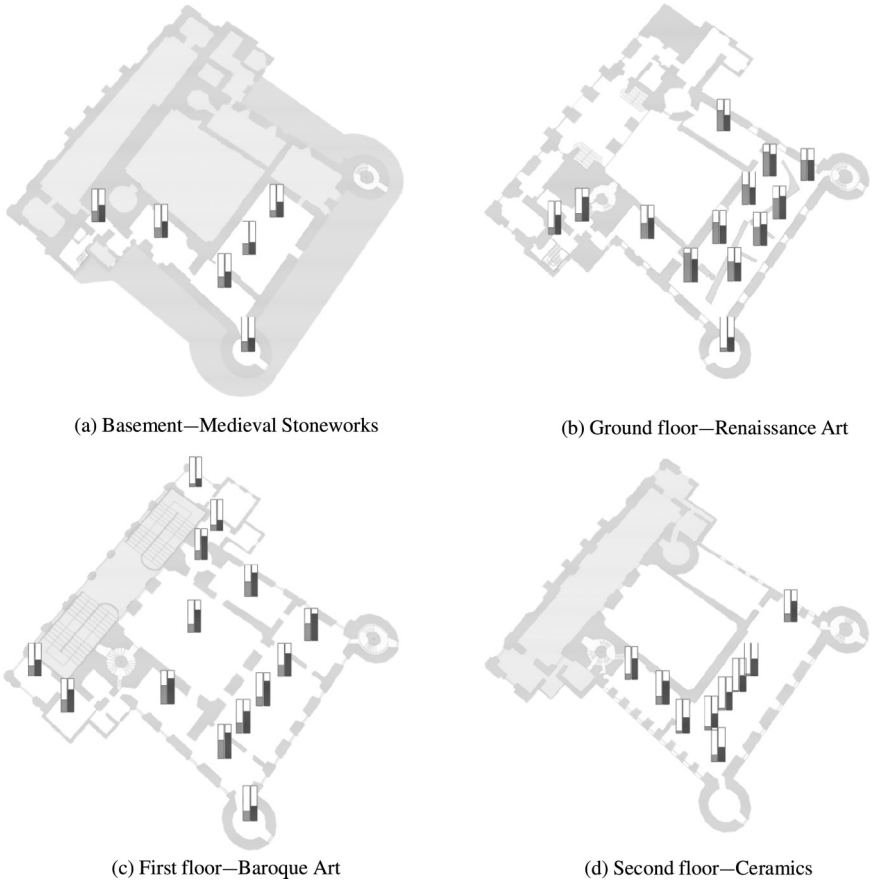


Fig. 8. Comparison of scanned markers on the different floors. Red bars represent users of "Gossip at palace," whereas cyan bars represent users of "Step by Step."

A deeper analysis of the data log shows that most users of both applications spend their time on the ground floor and the first floor of the building: this phenomenon is generally observed as well for people visiting the museum by themselves, and it can be related to the different nature of the collections displayed and to a natural decrease in the visitors' attention, regardless of the digital support employed. However, the analysis of the percentages of users who interacted with the single markers placed in the different locations pointed out that the game was more effective than the multimedia guide to encourage players to also explore the basement and second floor of the building.

Figure 8 shows the comparison of scanned markers on the different floors of the museum. If we exclude the ground floor, users of "Gossip at palace" tend to explore all areas devoted to museum exhibitions at a higher rate, especially the less prominent ones.

Overall, the combination of the results stemming from the analysis of the data log and from the evaluation of the knowledge acquired through the game suggests that "Gossip at palace" promoted an exploratory style of visit, where players visit a large number of rooms but mainly retain only a basic level of information.

5. CONCLUSIONS

This article has investigated to what extent a location-based mobile game with educational purposes has been appreciated by an audience segment, such as teenagers, providing evidence that an approach of this kind is not only generally enjoyed by this target but also can foster the acquisition of historical knowledge, at least at its basic level. Evaluation has pointed out that the digital storytelling gaming approach offers significant learning potential, and the appeal of the story is capable of overcoming fatigue related to the reading activity. Results stemming from our evaluation have pointed out that the use of the game "Gossip at palace" could be extended either to children or adults, depending on the objectives the museum prefers to prioritize: in fact, on the one hand, the game mechanics excite the enjoyment of the youngsters and thus satisfy an entertainment goal, and on the other hand, the communication of cultural contents through storytelling seems to be effective, especially with adults. These considerations confirm what the literature frequently points out—that balancing the entertainment and learning component is extremely challenging, especially when considering the needs and characteristics of a large variety of audiences. The analysis of the data log automatically collected by the mobile system shed light on the influence of the mobile game on visitors' interaction with the cultural contents and the environment: in fact, the game proved to be more effective than a multimedia mobile guide to stimulate users' curiosity and will to scan the visual markers deployed in the museum, inducing them to explore even the less prominent exhibit areas.

The adoption of a mixed-methods perspective in the study also allowed other lessons to emerge. Firstly, it was found out that the communication style played an essential role in users' perceptions and thus needs to be calibrated carefully. Some adults particularly refused to try the game as soon as they had a quick look at the application, saying that the game presented a layout that was too childish. Thus, a cartoon-like style that stimulates children may prevent adults from using the game, nullifying the learning and entertaining potential of such an application. Secondly, game length should not be overstretched: physical fatigue, time restrictions, and cognitive overload may influence visitors' intentions to actively explore cultural venues, regardless of the appeal of the game mechanics and the stories told. Abandoning the game before its actual end leads to a sense of frustration that compromises the experience. According to the users, an optimal balance between content provision and the keeping of user's attention should be about 1 hour. Thirdly, the adoption of game mechanics entailing the acquisition of points and badges fosters visitors' motivation and will to explore the museum environment, not only to satisfy curiosity but also to enable a sense of personal reward. Finally, it was found that traditional evaluation methods are not fully appropriate to investigate the mobile learning taking place in informal educational settings: as a consequence, new approaches capable of both capturing the acquisition of knowledge and investigating the changes in attitude and awareness are thus required.

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