Step by Step: Exploring Heritage Through a Mobile Augmented
Reality Application at Palazzo Madama - Museo Civico d’Arte Antica (Turin, Italy)

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1. Heritage, visitors and mobile technologies

The portability, multimediality and interactivity of the newest generation of mobile technologies are providing museums and historic venues with fresh opportunities to communicate and promote both collections and built heritage sites (New Media Consortium 2012; Proctor 2011). One of the most important objectives cultural institutions usually aim at when investing into the implementation and deployment of an application for smartphone or tablet is ultimately facilitating visitors' engagement. The reasons behind this phenomenon are twofold: firstly, there is evidence that engagement facilitates visitors' meaning-making process [Csikszentmihalyi and Hermanson, 1995]; secondly, engagement may contribute to the overall quality of the visitors' experience, not only encouraging a positive attitude towards the institution and strengthening the willingness to return to the venue, but also boosting the word of mouth, being it traditional or electronic. The use of mobile technologies to enhance visitors' engagement can thus be seen as a way museums may want to embark in both to better fulfil their educational mission and to gain additional revenues, directly or indirectly.

Given that museum scholars have underlined that a meaningful physical and cognitive orientation frequently represent an issue for museum visitors [Bit-

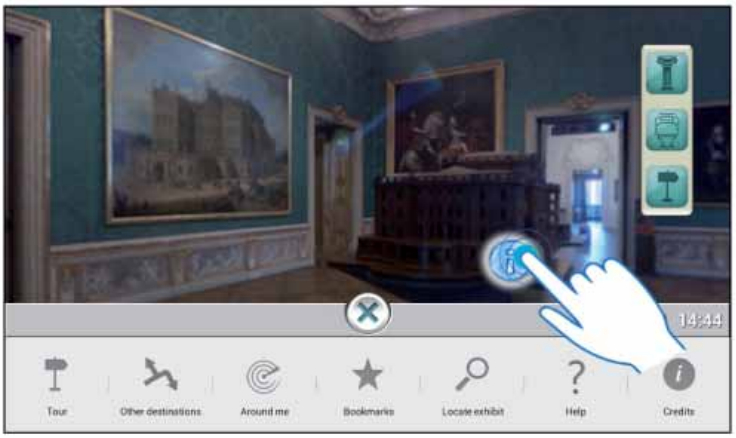
Fig.1 - Palazzo Madama - Museo Civico d'Arte Antica (Turin, Italy)

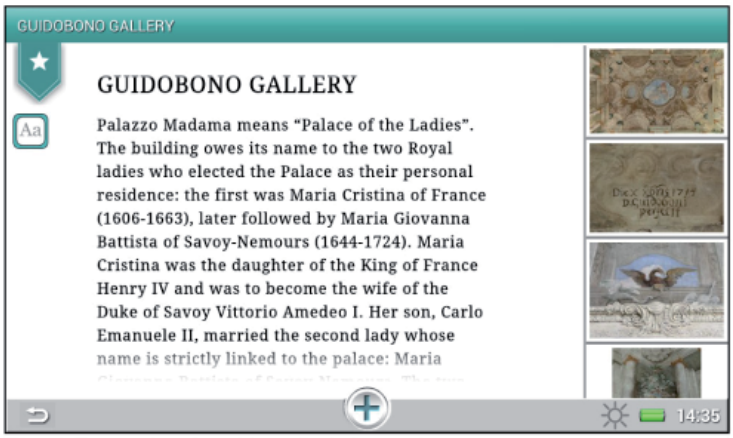
good, 2006], augmented reality (AR) and mobile navigation systems can be promising solutions [Quigley, 2013; Dupont, 2012; Perry-Lube and Lefkovitz, 2011; van Hage et al., 2011], especially in complex and multilayered cultural heritage venues.
More specifically, the use of AR has the potential to enrich the museum context with information that would be otherwise not perceivable, whereas navigation systems could help visitors locating themselves and guide them through paths identified by a dedicated application or decided by individuals.
Coherently with this framework, Palazzo Madama-Museo Civico d'Arte Antica (Italy,Turin) decided to develop in cooperation with the engineers of TonicMinds s.r.l. "Step by Step", a mobile AR application for tablet to be installed into a set of 7 inch tablets freely available at the museum ticket office (fig.1).

2. "Step by Step": a mobile AR application for a cultural heritage context

Palazzo Madama is a UNESCO-listed historic building located in the city centre of Turin (Italy); this venue is especially renowned for its 18th century baroque architecture, but it also presents architectural remains dating back to the Middle Ages and the Roman period; in addition, its cultural value is further enriched by the sculptures, paintings and decorative arts collections of the Museo Civica d'Arte Antica, on display on the four floors of the building. The development of the application "Step by Step" was thus intended to suit and communicate the composite identity of Palazzo Madama, fostering engagement and a positive visitor experience.
In order to enable an informed exploration of this cultural venue and overcome the absence of wi-fi connection inside the building, it was decided to

Fig.2 - Exploring the built heritage, its art and history; Fig.3 - Exploring the works of art on display inside the museum; Fig.4 - Example of multimedia information; Fig. 5 Example of thematic trail accessible through "Step by Step"





experiment the use of an innovative visual-based system. Markers featuring ARRU technology [TonicMinds, 2012] were unobtrusively positioned in selected points of the building, as to allow visitors to scan them with the tablets borrowed at the museum entrance and access a variety of information, such as 360o photos, texts and additional images of usually unnoticed details, restoration campaigns and related works of art (fig.2-5).
Visitors were given the choice to explore the museum and the architecture on-demand -accessing information when desired- or to follow one of the three thematic trails that were developed. In this occurrence, visitors were guided from stop to stop by the innovative ARRU navigation system: thanks to its algorithm, the system is in fact able to locate the position of the visitor inside the building, indicating the direction to be taken in order to reach the following stop (fig.6-7).
Coherently with an audience-centred approach, Intrigue at the museum, a game addressed to children aged 7-13 years visiting the museum with their families in the free time was developed too. The goal of the game was to uncover a hidden thief among a set of characters, solving a variety of mini-games (quizzes, riddles...) in order to find the clues (fig.8-9). The game was designed taking into account the experiences carried out by international museums [Thian, 2012; Mannion, 2012; Botturi et al., 2009] and following the gamification principles suggested by authors [Zichermann and Cunningham 2011].
With the aim of investigating to what extent the application met the pre-set objectives and identifying patterns of use as well as areas of future improve-

Fig.6 - “Step by Step”: the trails and the game; Fig.7 - The navigation system

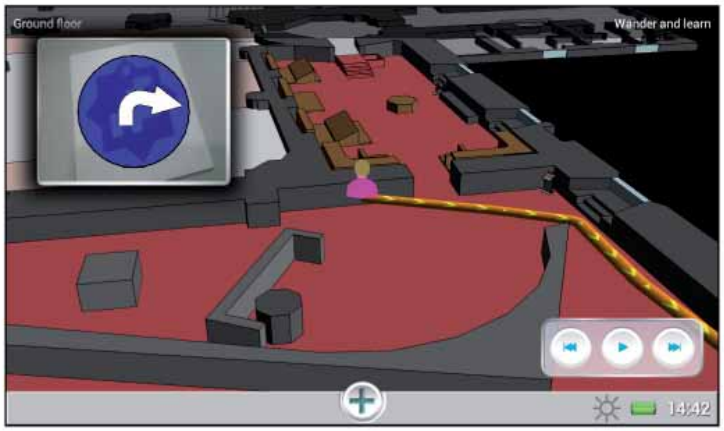


Fig.8 - “Intrigue at the museum”: integrating AR in a mobile game; Fig.9 - Mini-games stimulate children to interact with heritag

ment, evaluation was conducted, combining quantitative and qualitative methods.

3. Exploring art and built heritage through "Step by Step": evaluation of the experience

Visitors who accepted to use "Step by Step" were asked to fill in a two-parts questionnaire, before and after their visit. The principal aim of the pre-visit questionnaire was investigating visitors' expectations, their level of familiarity with mobile devices, the museum and cultural institutions in general, the social context and the motivations of their visit [Falk, 2011]. The post-visit set of questions aimed at identifying visitors' degree of appreciation towards specific functions of "Step by Step" and the application as a whole.

During the evaluation phase, 171 questionnaires were collected. The analysis of the results pointed out that the vast majority of participants were first-time visitors (75%), adopted an exploratory behaviour accessing information on-demand (76%), had recreational motivations and decided to use the application since attracted by new ways of exploring cultural heritage sites.

Among the facilities enabling visitors to access and interpret information, 360o photos were the most appreciated feature (8.15/10), most likely for their intuitive look allowing visitors to easily shift their sight from the display of the tablet to the museum environment.

On the contrary, texts and trails were less appreciated and in some cases they were reported as elements distracting from the museum environment, being attention and time consuming (tab.1).

Even though the test of the usability and accessibility of the application pointed out that some elements of the interface could be improved (tab. 2), results underlined that the use of "Step by Step" positively contributed to the quality of the experience. Additionally, the most part of the people who completed the

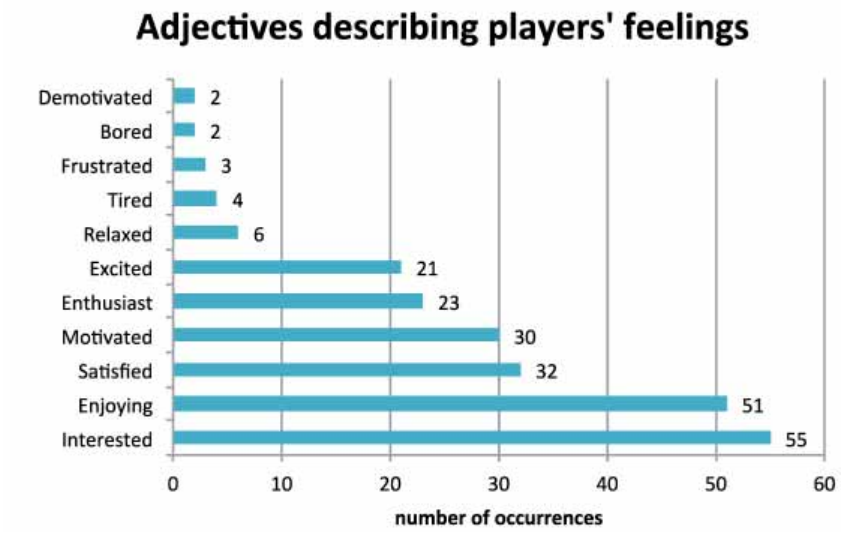
Table 1 The degree of appreciation manifested by visitors; Table 2 Step by Step: degree of usability and accessibility

FEATURES OF THE MOBILE APPLICATION "STEP BY STEP"	Average rate (10 points Likert scale)
Panoramic/360° photos	8.15
Photo-galleries (additional images, details, etc.)	7.76
Navigation system	7.39
Thematic trails	7.35
Texts about history and the works of art on display	7.06
Overall enjoyment of the experience	7.97

ACCESSIBILITY AND USABILITY	Level of agreement (min.1 - max.10)
Was it easy to find the markers in the museum environment?	7.80
Was it easy to access the information about the works of art?	8.03
Was it easy to understand the directions suggested by the navigation system?	7.47
Was it easy to understand the meaning of the icons used in the application?	7.92
Was it easy to navigate through the multimedia contents?	7.58
Were texts easy to read?	8.42
Were the texts about the works of art enough detailed?	7.35
Was the quality of the image high?	8.12
Was the quality of the texts high?	8.08
Did you find the guide useful?	7.91

questionnaires manifested a positive attitude towards the potential payment of a variable amount of money for the service (64%). The patterns of use emerged through the analysis of the questionnaires were further investigated through the conduction of 34 semi-structured interviews, which mainly provided suggestions for the improvement of the interface.
The evaluation of the game *Intrigue at the museum* was first of all conducted through 30 unobtrusive observations focusing on children's interaction with the museum physical environment, the works of art on display and the peers or adults accompanying the young players. Results pointed out that the game was effective in fostering engagement: in fact, 83% of young players revealed one or more signals of engagement (i.e. hunting markers, walking faster, pointing at markers while saying aloud sentences such as: "Look!"). A positive and purposeful interaction with the works of art on display was registered at least for 56% of the players, whereas the analysis of players' behaviour pointed out that the social interaction among young players and adult companions or peers was on-topic at least for the 73% of the sample observed (fig.10-11). These results were reinforced by the data extracted from the questionnaires

Graph. 2 Young players' feelings, as described by adult companions; Fig.11 - A child interacting with the AR mobile game



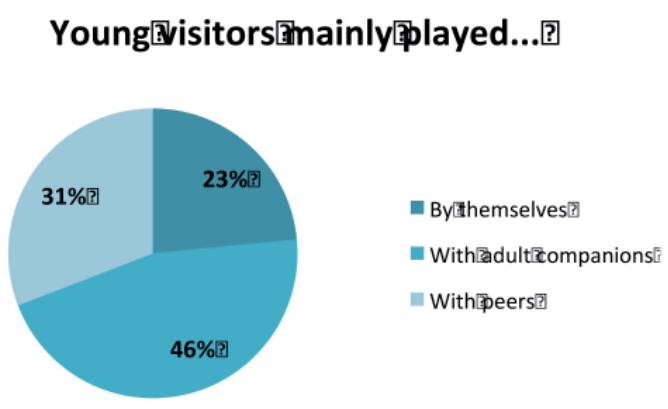


Fig.10 - Social interaction occurring when using "Step by Step"; Graph. 2 Young visitors mainly played collaboratively

completed by 81 adult companions after the visit: collaboration was registered for 76% of respondents (graph. 2). The feelings manifested by children during the visit were described with adjectives that had almost exclusively a positive connotation, indicating the effectiveness of the game in facilitating an enjoyable visit (graph. 1).

4. Conclusions and future areas of research

The evaluation of "Step by Step" has reinforced the concept of AR mobile applications as tools that may facilitate the orientation process and the quality of the cultural experience. However, the particular appreciation towards 360o photos, combined with the preference manifested by visitors for the following of their own paths, suggest that mobile applications should take more into account visitors' motivations and social context [Falk, 2011] in order to best suit their agenda, foster engagement and ultimately boost the spreading of word of mouth. As a result, future work will focus not only on the improvement of the user experience, but also on the provision of a higher degree of personalisation and user control over the application.

Given the results concerning the purposeful interaction fostered by the game Intrigo al museo with the museum environment, the works of art on display and the social components, a gaming approach for adults could represent a possible scenario for the future.

Finally, considering that some visitors found reading texts both attention and time consuming, it may be suggested that mobile applications should capitalize more on the multimedia capabilities of the devices, making the exploration of the art collections and the built heritage more engaging and immersive.

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