Enhancing User Experience in Points of Interest with Augmented Reality

Fernando Vera, J. Alfredo Sánchez, and Ofelia Cervantes

***Abstract*—This paper presents an approach to designing the user experience for interactive systems in open scenarios that involve augmented reality and mobile devices. We discuss the methodology we have used, which is a variation of contextual design, and resulting prototypes for a platform that will provide functionality for users to interact with augmented reality features in cultural and historical places, which are referred to as *points of interest*. Also, we report on preliminary results of the evaluation of our prototypes with potential users.**

***Index Terms*—Augmented reality, contextual design, gamification, point of interest, user experience.**

I. Introduction

Augmented Reality (AR) is a technology that adds information to the real world and what we perceive in a context. This gives users the opportunity to enrich their experience in the location they are standing. AR applications can be characterized by three main features: They combine the real and virtual, they are interactive in real time, and they register information in the real world in 3D [1]. AR allows the user to see the real world, with virtual objects superimposed upon or composited with the real world.AR supplements reality, rather than completely replacing it. Ideally, it would appear to the user as if virtual and real objects coexisted in the same space.

Points of interest(PoIs) in urban areas offer opportunities for taking advantage of augmented reality technology, both in the area of promotion materials (such as guidebooks, websites and multimedia contents), and in the actual sites that represent points of interest from cultural, historic or other perspectives. Advances in realizing the concept of smart cities are taking place along diverse dimensions, including, for example digital government, citizen participation and environmental protection.

In the context of smart cities, AR content extends human perception, enabling people to interact with their surroundings in new ways. The use of novel technologies in PoIs can give users another perspective of their context by augmenting what they perceive in historical places such as museums and archaeological sites.

Envisioning new, open scenarios with mostly intermittent users, in which augmented reality will be introduced, and designing the experience of users with novel interfaces, have become challenges that need to be addressed with existing and new methodologies [2]. We have been exploring the application of Contextual Design in this sort of scenarios.

This paper provides an overview of the state of the art in the use of technology to enrich the experience of visitors of points of interest in smart cities. In particular, the work were viewed is focused on technology that enables augmented reality, social networks and gamification in the context of museums. *Reaumobile*, a specific project that involves all these concepts, is described as a case study, with emphasis on the use of contextual design during its early exploratory stages.

The remainder of the paper is organized as follows: Section II presents work related with the use of technology in museums. We review technologies such as mobile devices, augmented reality and their key elements of interaction. We focus in particular on innovative technologies used in museums. Then, Section III introduces *Reaumobile*, as well as the contextual design methodology used as the basis for incorporating AR into PoIs. Sections IV-VII provide details of the application of the main stages of the contextual design methodology. Section VIII presents results of initial user studies. Finally, Section IX presents preliminary conclusions and ongoing work.

II. Related Work

There are numerous examples of research projects that introduce technology in museums in order to enhance user experience. In this section, we first discuss how technologies such as mobile devices and augmented reality have been provided in museums for users to interact with their context. Then, we describe salient interaction principles, which include two relevant features in *Reaumobile*: Personalization and gamification. Projects developed by other researchers that apply technology in museums are also presented.

A. Technology Used in Museums

Recent advances in technology affect our daily life in various aspects, providing access to different sources of information in novel manners. One of the most mentioned technologies in museums refers to mobile devices [3]-[8]. Both smartphones and tablets are part of intended concepts. On top of that, mobile technologies have penetrated and transformed society in various ways, as they have become an integral part of our lives. They allow for both access control and personal storage and could give users a greater sense of privacy. Smartphones could become the gateway to interact with ubiquitous computing applications. They are equipped with many input and output features that can be used to enhance user interaction [7]. Such features include [4]:

1) Reality view: Capturing images via the smartphone's video camera in real time.

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2) Registration and tracking: Aligning virtual objects within a 3D coordinate in the reality view (using GPS, compass, accelerometer).
3) Virtual objects: Representing digital content with augmented reality.
4) Markerless and marker-based AR: Detecting and identifying either artificial markers or natural features of objects in the real world.
5) Location-based tracking: Obtaining geo-referenced information.
6) Six degrees of freedom: Applying six tracking actions that smartphones can support: forward /back, left/right, up/down (GPS), Yaw (compass), Pitch and Roll (accelerometer).

These features could transform mobile devices into interfaces through which visitors could interact with interactive displays, explore museum exhibitions or download content to their mobile phones [7].

Other noteworthy technologies are large screens and their variations, such as interactive projected screens or multi-touch displays. The main promise of such large screens is to overcome the small interaction surface of mobile devices.

In addition to the aforementioned technological possibilities, it is pertinent to point out the emergence of the Internet of Things. In the Internet of Things, devices as well as objects, people and spaces become part of a network of interconnected entities. They gain their own identity in the physical as well as the virtual environment. While the technology remains unobtrusive, this allows localized user interaction to provide user specific content [5]. Various tracking technologies support personalized interactions with mobile devices and large screens. These include, for example, QR (Quick Response) codes [5], [8]; RFID (Radio Frequency Identification) technology [7]-[9]; NFC (Near Field Communication) technology [5]-[7] and IR (infrared) cameras [9]. Last but not least, vital additions to the technologies just discussed could be AR browsers such as Wikitude, Layar, and Junaio [10] or even haptic interfaces.

B. Interaction with Technology in Museums

Technology acts as an intermediary to translate or interpret content to the users. Therefore it is important to mention some general principles, which should be kept in mind when designing with technology.

A primary principle states that any interpretation that does not somehow relate what is being displayed or described into something related with the personality or experience of the visitor will be sterile. Another principle states that interpretation should aim to present a whole rather than a part, and must address itself to the whole man rather than any phase. Finally, it is key to consider that the aim of interpretation is not instruction, but provocation. Moreover, interpretation addressed to children should not be a dilution of the presentation to adults, but should follow a fundamentally different approach [11].

Human factors are important aspects in the interaction with technology [3], [12]. For example the fact that museums are being visited in pairs or groups is mentioned in [3], [6]. This makes museum visits a matter of socially spent time. A tightly connected insight is that people want to use these visits for filling their leisure time with new experiences, worthwhile activities and learning [6], [7], [12]. In general it could be said that visitors are looking for active participation, during which they are self-paced and self-directed (what and when to see) co-exploring exhibits and sharing private experiences [3], [6], [7]. Finally, there is a tendency to keep those memories after the visit [3]. The behavior of visitors is reflected in two key concepts: personalization and gamification.

Personalization is an interface feature based on a continuous process of collaboration, learning and adaptation between the museum and its visitors [3], [8]. The primary reason to strive for a personalized experience is to evoke emotions, because an event has to matter to the person experiencing it in order to cause some emotions [13]. Benefits of emotional interaction are deeper, longer lasting learning and higher engagement of users.

A first level of personalization is a museum considered as an interface itself, since visitors are choosing interesting places on their own. Other levels of personalization, achieved by technology might take different forms and happen in different phases. At the very beginning, before a museum visit starts, it is possible to use social networks [8], questionnaires, or select predefined characters in order to characterize users [3]. Once a visit starts, visitors follow essentially two approaches for determining what they will see: Content-based filtering and collaborative filtering. In content-based methods, the common features among the contents selected by a visitor are analyzed and recommended those contents that have similar features. Collaborative methods involve searching for peers who have similar known preferences and then recommend contents that were most favored among the peers. Also, there is a hybrid approach that combines collaborative and content-based methods in order to use benefits of each separate method [14].

Communication is partially connected with personalization. In order to support this aspect, there are various tools such as leaving comments, instant messages, visit diaries [3], which address different needs through the actual visit and post visit experience.

Gamification is an emerging trend in which many day-to-day tasks are enhanced by applying game mechanics in a way that adds an element of fun to otherwise dull and repetitive activities [15]. This is the perfect moment to use gamification, since mobile phones have reached masses and commoditized GPS and mobile internet. A good example of the use of gamification is Foursquare, a location-based application used to exchange check-ins in physical spaces for badges and trophies. It applies most of the common game mechanics: points, badges, leaderboards and incentives [16].

Two types of games have been modeled in [17]: Methods of progression and winning scenarios. It describes a series of games developed to investigate how real-world activity could be incorporated into digital game systems. By incorporating real-world actions and behaviors into digital games, experiences that both enhance our understanding of the world around us and provide incentive structures towards our personal, community, or societal goals can created. Based on their proposal authors consider that a "game is a low-risk, high reward situation, and is, in some ways, a way of distracting ourselves into doing something positive."

The concept of gamification has the potential to improve

the engagement of users and provide possibilities for generating new business models, which can be based on such strategies as points earned or leadership boards.

C. Projects Implemented in Museums

There are various projects focused on the use of technology in order to improve user experience on points of interest, specifically museums. The projects described here use technologies such as multi-touch surfaces, QR codes, RFID, NFC, augmented reality and others.

Several exhibitions in museums have used multi-touch technology. In ONNA Museum [8], the Onna surface is an interactive exhibit for the museum of Onna, Italy. The concept works in two stages, indoor and outdoor experience. The first stage starts at the entrance of the indoor system, when the visitor receives a personal badge and then installs the Onna mobile app on the smartphone. After associating the badge with the personal profile on the mobile app via a unique identification number (ID), the visitor is able to interact with the immersive installation. The system monitors which asset is played and how much time the visitor focuses his attention on a particular content. Thus a personal profile of interest is built in the indoor system and then linked to the visitor via the ID. The second stage occurs when visitors leave the exhibit and go outdoors into the town. While they are visiting various areas of city, they can activate the app (connected with the data collected in the outdoor system). The mobile phone app shows information based on the actions performed inside the museums. There are two modes, proposing a path through the town, and providing in depth information from museum about a specific location.

Another case that illustrates the use of mobile devices is SYTIZEN [5]-[7]. In this project, museums hold various exhibits and with using various technologies (RFID chips, NFC, interactive displays, mobile devices) the mobile environment could turn into a large network of interconnected entities. In a museum environment, a number of artifacts were displayed and fitted with NFC tags. When users touch an artifact's NFC tag with their mobile phone, information about the artifact is shown on the mobile phone. A display next the artifacts show a 3D model and a 360-degree overview. The smartphones 3D rotation and touch information was used to control the model. Finally, the artifact was collected and users were able to view a list of their collected artifacts and view its information at any time.

A use of geo-located applications can be found in the Howard Family site [12]. This concept still needs to be evaluated. In theory, the mobile app enables geo-located AR of the artifacts found at the site to tell stories about their relevance. There is a narrative associated to the physical exploration of the site. Using GPS location, the app can test whether the user is onsite or offsite. If on site, the user will be able to explore and access interest points by walking to them, or by selecting the points directly on the interactive map.

A natural way to deploy augmented reality is via markerless techniques, as used in US Census [9]. This project introduces a markerless approach towards personalization. The developed model merges input from an RFID reader with input from a commercial camera-based tracking system. Furthermore, a probabilistic Bayesian model was developed to infer at runtime the correct identification of the subjects in the camera's field of view.

In pervasive systems, technology has to be context-aware. In the PIL project [3] the scenario of technology-assisted museum visits from a broad perspective (in addition to actual visits and even pre- and post-visit experience) was considered. A museum visitors' guide system is initialized with a user profile and then, in the course of the visit, adapts to the behavior of the visitor, proposing context-dependent presentations, ordered to best fit the visitors' perceived interests (based on the user's liking or disliking the current piece of presentation). Additionally, intra-group communication is supported by sending immediate messages to each other or leave virtual post-its on exhibits.

Adaptive augmented reality is introduced in ArtSense [14]. This concept enriches human perception not only through visual augmentations but also through a continuous monitoring and augmentation of the human auditory perception, all by taking into consideration the monitoring of the affective quality and impact of the physical and digital stimuli that may have an influence on perception, cognition and behavior.

The work discussed above provide support for the use of mobile devices. Also, AR markers are useful to deploy augmented reality in an accurate way. A distinctive characteristic of the *Reaumobile* project, discussed below, is the design approach. Reliance on Contextual Design has allowed us to explore multiple design alternatives and to obtain interesting results, which we report next.

III. *Reaumobile*: Contextual Design

This section introduces *Reaumobile*, a project aimed to incorporate augmented reality into the context of points of interest in a smart city, particularly through the use of mobile devices. The project involves prototyping applications based on augmented reality using mobile devices in order to provide interactive information for tourists on objects of interest (OOI) at points of interest (Fig. 1). Based on the concept of smart cities, the proposed applications also seek to link people with similar interests in points of interest. They allow to share and gain knowledge about these elements and to promote and disseminate user profiles associated to information. The project seeks to integrate the tourist's experience with expert communities that provide information associated with the PoI.

We have applied the technique known as Contextual Design (CD) [16], which focuses on the user and the tasks performed in a given context. It is important to emphasize that our work was conducted in museums and open spaces around it. CD consists of the following phases: (1) Contextual inquiry, associated with data collection; (2) Model formulation, focused on the interpretation of the collected data, integration of models related to the discovery of patterns; (3) Storyboarding scenarios, which focus on brainstorming sessions based on patterns found and the development of support scenarios; (4) Prototyping, which focuses on testing design ideas and prototyping low and high fidelity interfaces to perform usability tests and design the user experience. (5) Usability studies, Users involved in the evaluation of prototypes have diverse profiles, including different age ranges and areas of knowledge.

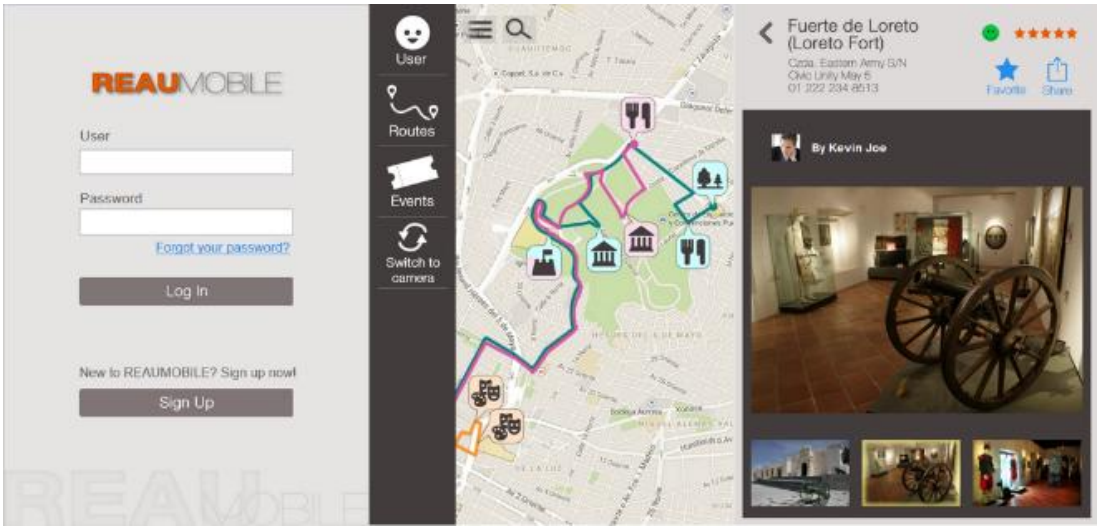

Fig. 1. *Reaumobile* prototype.

Fig. 2. Interviews at Los Fuertes.

IV. Contextual Inquiry

We visited an historical point of interest, known as Los Fuertes (a former military facility that has been transformed into a cultural and recreational area), in the city of Puebla, Mexico and interviewed people involved in various activities there (Fig. 2).The museums narrate the history of the Battle of Puebla that took place on May 5, 1862 during the French invasion of Mexico. Our study was conducted in the two museums located in the forts.

In this place we interviewed the administrator, visitors and we observed visitor's behavior in order to understand the way they interact in open spaces.

V. Model Formulation

As part of the contextual design, models were created that allow us to understand the context and the needs in the forts (Fig. 3). To represent and reflect the information collected we used 5 different models, as prescribed by CD: flow, cultural, sequence, physical and artifacts models. The models enable to visually understand the structure of the place, the interactions that take place and the items used. We thus gained insight into the cultural and technological issues in this particular point of interest.

We held brainstorming sessions guided by the results of the models. These results led to the creation of support scenarios about the user interaction augmented reality technologies to improve the experience of the visitors of PoIs.

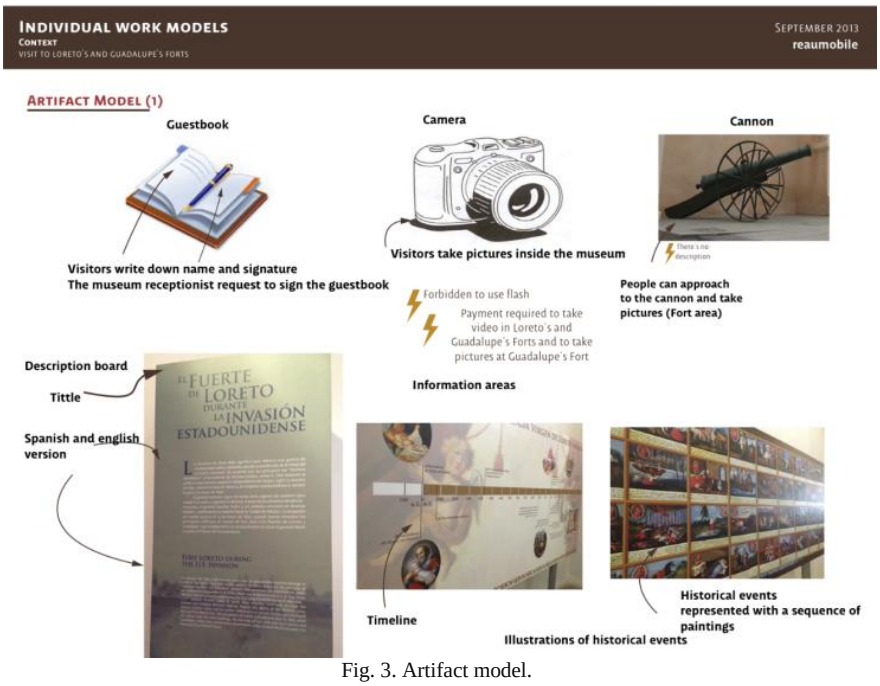

Fig. 3. Artifact model.

VI. Scenarios

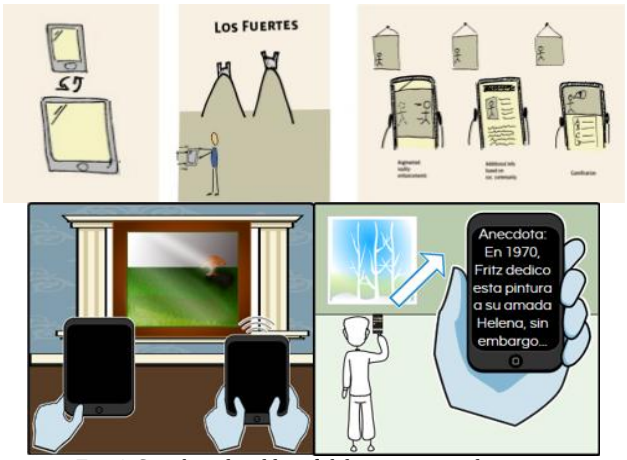

Fig. 4. Storyboard and low-fidelity prototype elements.

Support scenarios were created from the information gathered in the contextual inquiry stage. This led us to propose elements for situations where the user experience is improved through technology. We created storyboards and low-fidelity prototypes (Fig. 4) as means of communication with users. The design ideas include gamification mechanics, animations in augmented reality focus on the OOI, and visualization of the main PoIs in a city.

We then obtained feedback from users, discussed scenarios, and selected those that were most appropriated for interaction in actual environments.

VII. Prototyping

In order to enhance the user experience with museums we applied gamification mechanics. The visitors interacted with augmented reality through gamification. They were able to look with a mobile device different use of AR. For example, users interacted with canyons in the forts, they answered trivias from a specific painting, saw more information about objects of interest and used a timeline to visualize the forts in the past.

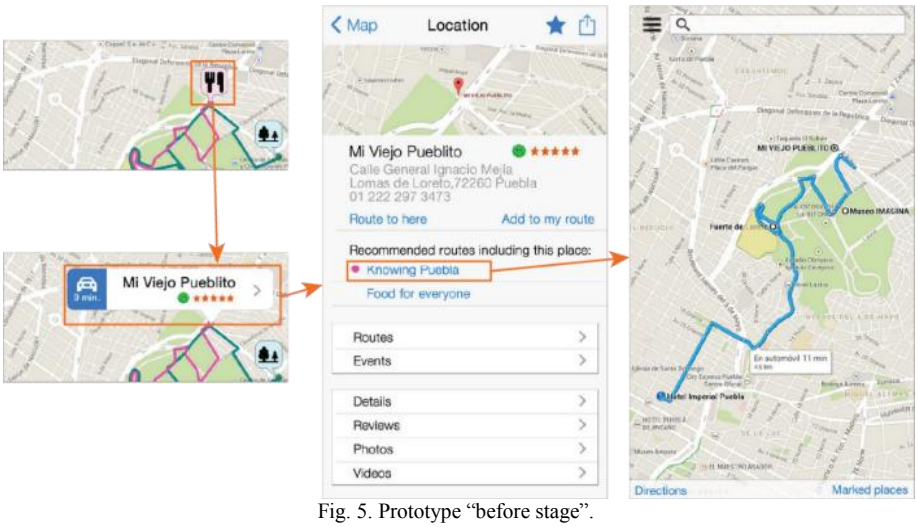

Fig. 5. Prototype "before stage".

Fig. 6. Prototype "during stage".

We developed a prototype which includes the main elements of our selected scenario. Interaction was divided into three main stages: *before*, *during* and *afterwards* the user's visit to the PoI.

In the "before" stage, the main focus was on routes of potential interest for the user (in a collection of PoIs). People have access to existing routes recommended by experts, and also can create their own (Fig. 5). Also, social elements such as comments and ratings entered by other users can be visualized.

The "during" stage focuses on the interaction with the points and objects of interest. In this stage, augmented reality is introduced (Fig. 6) via the notion of missions as well as via interactive maps. The interaction follows a gamification mechanics where the user has the option to carry out missions, which require the user to accomplish goals, such as finding specific museum areas or OoIs. Missions allow users to interact with heir context and other users in a novel way by playing roles related to the historic period of OoIs, and also earn rewards. Users receive notifications when new missions area available, but gamification functionality is optional.

In the "afterwards" stage the user can exchange the points earned by products or services (Fig. 7), and also they can access their scores in the *Reaumobile* social network.

User interaction with *Reaumobile* applications takes place before and after visiting a PoI using a mobile device such as a smartphone. However, in the current version of the prototype the interaction with more detailed augmented reality is only available on iPads (Fig. 8) that are strategically located in PoIs.

The augmented reality marker displays a 3D model in which the user can interact with the elements on the screen. This scenario is focused on the Battle of Puebla in order to the visitors understand the theme of the museum.

In the 3d model the user see an animation of how this battle took place, likewise the user may interact with the model to display videos from this topic.

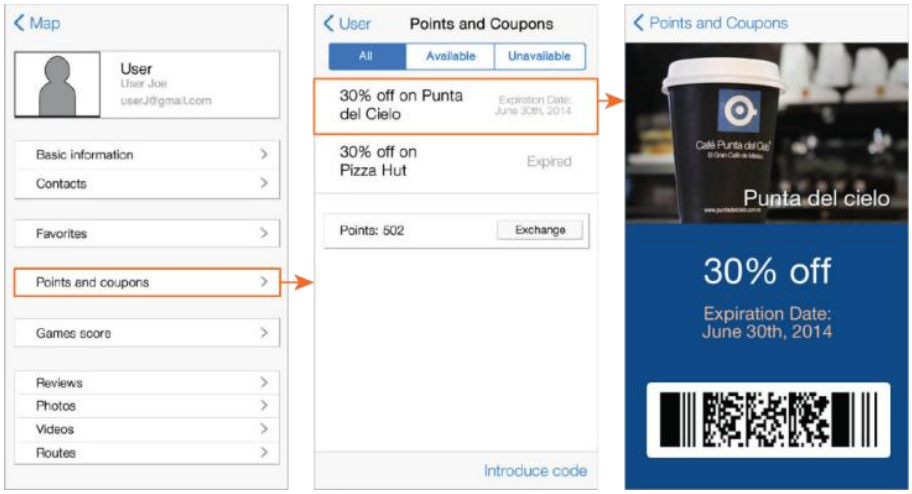

Fig. 7. Prototype "later stage".


Fig. 8. Augmented reality deployed using tags.

VIII. Usability Studies

The aim of the evaluation performed on the prototype is to learn about opinions of the public to whom it is addressed, analyze what is so intuitive for users, uncover potential usability problems and generate new ideas for future implementation. A total of 8 subjects were recruited for testing (Fig. 9). Local and international users of different ages participated in the evaluation of prototypes. User experience was evaluated by taking into consideration whether the interface was intuitive and attractive to all age groups, regardless of their background. Shadowing techniques were also used to understand user's behavior when they interact with the augmented reality prototype.


Fig. 9. Usability studies with potential users.

The objective of the evaluation was to detect usability issues and the acceptance of the ideas represented in the prototypes. The main areas of interest and to which more attention was given were:

- The potential of augmented reality. The users also commented on the AR prototype. Among the interesting comments, the following were noteworthy:

1) "It makes the experience more real."
2) "The timeline made it interesting to see what something

looked like in the past."

3) "Probably clarify the intended audience, since adults and children may prefer different options."

In addition, the users where interested in the following features of the prototype:

1) The simplicity in the use of buttons and menus.
2) The ease to interpret the symbols used in the interface.
3) The ease of visualization and creation of routes in the city and inside the museum.
4) The user involvement with the museum through missions.
5) The interest in trivia and games.
6) The motivation to use the application.

According to these features we have the results presented in Fig. 10.

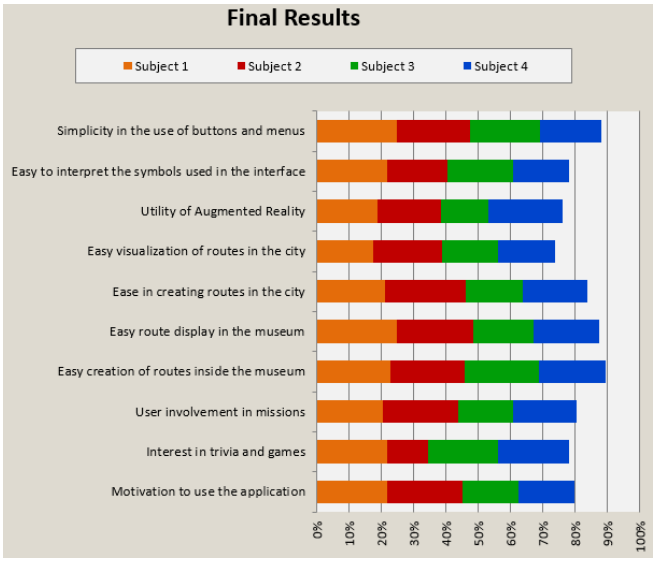

Fig. 10. Usability studies results.

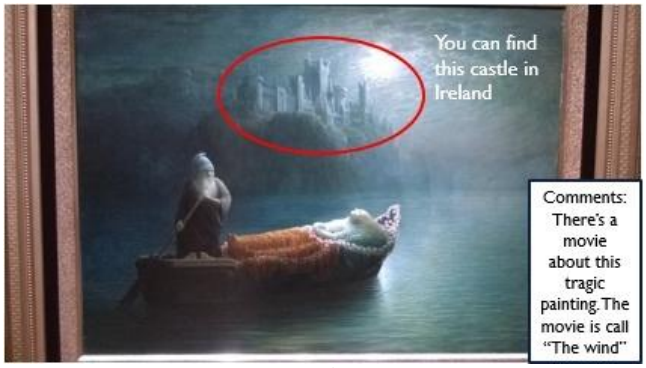

Fig. 11. Example of AR annotations.

The main findings were observed by this study were:

1) Most of the application components are intuitive.
2) Only few interface elements cannot be interpreted in a straightforward manner.
3) Creating and viewing routes in both the city and the museum are considered useful options.
4) Textual information is preferred by some adult users
5) The use a tablets inside the museum is tiresome, as their focus must remain in one position.

We also conducted a focus group, in which observers and experts met to comment on the events during the usability study, the views of users and potential improvements to the prototype. Among other results, the following are important:

1) Simple Interfaces. Keep interfaces simple, especially when they are required to be used outdoors because to many options can be confusing
2) Timeline. Keep timeline active in order to use it in different POIs.
3) Accessibility. Leave only the most important application utilities in the home screen.
4) Cost of application. Regarding the cost of the application, most users suggested it should be free, as they find this to be customary.

IX. Ongoing and Future Work

Contextual design was used as a methodology to understand how visitors interact in points of interest and to propose the use of novel technologies to enhance their experience in the places they visit.

The integration of gamification mechanics with augmented reality motivates people to use this technology as a new way to interact with objects of interest and improve their experience.

We also noticed that although the visitors experience was more realistic in some objects of interest, some users think that children would enjoy the experience better.

In the next research stage, we will take the results of the usability study as requirements for the next prototype. We will focus on gamification and augmented reality as the main mechanisms in order to improve the user experience.

Users are able to interact with AR in real time but we also plan to provide functionality so they can create their own AR content. People that visit a point of interest will be able to make annotations in real time on objects of interest (Fig. 11).

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