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Location-based mobile applications to experience collective memory

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Abstract

Mobile learning technologies can provide an important added-value to cultural tourism by supporting visitors in their direct field experience. Providing engaging experiences is a key factor to the success of educational and entertainment products. We have researched how mobile gaming can help tourists and citizens enhancing their experience when interacting with Cultural Heritage. GeoJoko aims at designing and implementing context-based mobile games that will allow users to enhance their experience about Cultural Heritage and collective memory. The prototype includes location technologies that provide the location of each of the players in real time. Contents can be both streamed in real time over the infrastructure provided by the Public Administration within the "wireless cities" concept or downloaded to the mobile device of the player. This approach is innovative since it exploits the challenge of location-based serious games in order to implement a mobile learning service that supports the user understanding the elements of Cultural Heritage.

Categories and Subject Descriptors (according to ACM CCS): H.5.1 [Computer Graphics]: Multimedia Information Systems—

1. Introduction

Modern information and telecommunication technologies offer a great opportunity to enhance the education and understanding of people about their Cultural Heritage and collective memory. IT can do this in many ways, from facilitating digital acquisition of data from pictures and relics to multimedia content presentations. Currently, people access cultural and arts information through interactions with desktop computers and other similar platforms. In this field, ubiquitous computing systems can make an important contribution by supporting people in the most important moment of their educational experience: when they are up close to the subject, whether they are viewing a painting in a museum, a monument in a park or an animal in the zoo.

Location-based games are one of the many areas where the concepts of ubiquitous computing come to life. Thereby, single players or teams perform tasks in specified scenarios using mobile computers like laptops, personal digital assistants or mobile phones in combination with wireless communication and tracking technologies, having the real world as their game board.

Within the framework presented, in this paper we introduce GeoJoko, which is an example of an innovative approach to location-based serious games that use wireless and ubiquitous computing technologies to create a linkage between the physical Heritage and new technologies. The project focuses on investigating how a computer game can improve visitorst' understanding of the Cultural Heritage and collective memory of the territory.

The project is based on a game structure that closely resembles a treasure hunt. Instead of finding treasures, GeoJoko aims at finding the right route to a given Point of Interest when visiting a city. Passing from one stage to the next is a critical aspect of the game. In the typical treasure hunt, players make this transition by solving an enigma. In this case, when the user is at a given location, he/she is provided with some kind of quiz in order to find the next stage. While

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following a path, players can check the map to determine their current position and desired direction.

The remainder of the paper is organized as follows. In section 2, we present work that has been done on the area of Location-based games in several fields. In section 3, we outline the basic description of the project. Section 4 presents the requirements of the system and gives a detailed overview of the technical concepts of the prototype. In the final section, we draw conclusions and outline future work.

2. Related work

A mobile game is simply a game that runs on a mobile device. Some mobile games use environmental space as playing ground. Moving beyond core information services, location-based experiences aim at providing the user with a richer experience that extends across a series of locations. These experiences extend digital media out into the physical world. Users move through the world equipped with a wide variety of mobile displays including PDAs, laptops, gaming consoles, mobiles phones and potentially even wearable computers. Sensors capture information about their current context, which is used to deliver them an experience that changes according to where they are.

Perhaps the most promising example is location-based games. A number of industrial and academic research projects have explored the idea of using geographical locations as a resource in a computer generated game. The possibility has been exploited by the industry, e.g. in Botfighters from It is Alive (`http://www.gamespot.com/mobile/action/botfighters/index.html`). Botfighters is a commercially available SMS game, in which players can track opponents, get their location, move and then fight them using phone cell positioning. However, the game does not adapt to the differences between the locations. Therefore, it presents the same tasks and context and background stories at a graveyard as on a motorway.

Some recent research projects have begun to directly explore the educational potential of location-based games. For example, Savannah is an educational game in which children learn about the ecology of the African savannah, specifically about the behaviour of the lions ([FCF*04]). Groups of six children at a time play the roles of being lions by exploring a virtual savannah that appears to be overlaid on an empty school playing fields, an open grassy area of roughly ninety by sixty meters. Equipped with handheld computers with WiFi networking and GPS, the children move around the playing field, exploring the varied terrain of the savannah and discovering the resources that lions need to survive.

Many of the previously mentioned examples have focused on experiences that are relatively small-scale, both in terms of geographic area and duration. One notable exception is Mogi, a location-based game for mobile phones and the web, which was launched in Japan in April 2003 ([Jof05]). It has over 10000 players, although only 1000 are highly active. Mogi does not relay on precise location or orientation, because many players use phones with positioning based only on GSM cells. The phone display uses maps that are heavily trimmed to show only the information most significant to the current context in game terms.

On the other hand, Augmented Reality games integrate the virtual world of the game with environmental space at a perceptual level. Widely acknowledged examples of such games are for example Can You See Me Now and Uncle Roy All Around You. Among the current examples of social interaction, the Uncle Roy All Around You (URAY) can be mentioned ([FBA*03]). It is an experience that mixes online and street participants, physical and virtual worlds, and programmed game-play with live performance. Street players walk through a city following clues on a handheld computer looking for the elusive Uncle Roy, while online players follow their progress in a parallel virtual model and try to help them.

Moreover, Can you see me now? is a mixed reality chasing game where online participants compete or collaborate with mobile participants on the street ([BCF*06]). Both games are played via a traditional screen-based GUI. The participants can also collaborate by communicating via a real-time audio channel while moving through the city streets. The game can be played where high bandwidth networking and digital maps are available. It must be mentioned that GeoJoko is not an Augmented Reality game, as there is no integration of virtual object in the experience provided by the game.

Another term that has gained popularity in recent years is pervasive gaming, meaning that the game experiences are interwoven with our everyday life. Pervasive gaming has been extensively studied in the iPerG project, which has developed augmented reality games. One example of this concept is Songs of the North, a mobile pervasive gaming experience that has been designed in connection with a scenario-based player study that aims at formulating general design requirements for pervasive mobile games ([LBA*04]). The game is a persistent multiplayer game that takes place in a semi-fantastic reality created on the basis of Finnish mythology.

Moreover, it cannot be denied that cities are composed of a myriad of different stories and memories, which have significant value in the Cultural Heritage of the place. It is vital to be able to give a voice to allow such local narratives of places to be showed, as it has been proposed in , that GeoJoko aims at designing and implementing context-based mobile games that allow users to enhance their experience about Cultural Heritage and collective memory.

For instance, the Hide and SEEK project creates opportunities for cultural knowledge transfer through a street game experience ([GMWG07]). The game narrative is based on the concept of sharing place-based knowledge. The treasure at the end of the game is not a material reward but rather the

construction of a shared social experience; the exploration and revealing of a place known to the Host and initially unknown to the Guest developing as a valuable artifact in the memory of both game participants.

Another example is ConQwest, a team-based treasure hunt game, that uses implied positioning from semacode tags. As the position of the player is implied, the game area must be set-up prior to the game by placing semacode stickers at defined locations around the selected urban landscape. Each sticker is given a relative value, the players collect the stickers by taking pictures with their phone cameras. The game has been played by teams, generally drawn from local schools in the USA.

Moreover, Treasure Hunt uses GPS to get location information, which allows players finding a virtual treasure by discovering different clues hidden at various locations. At the beginning of every game, players are given a picture or video clue followed by a number of multiple-choice answers. Users have to pick the correct answer to unveil the location of the next clue. The user then navigates around the virtual world picking up items and new clues.

Finally, the main target of VeGame is to offer a pleasant and useful tourist experiences in the urban context of the city of Venice ([BBG*04]). The experiences relies on active exploration of the territory, its people and their activities, in order to have a better understanding and appreciation of the Cultural Heritage of the city.

3. The GeoJoko project

The main target of GeoJoko is to offer a pleasant and useful tourist and cultural experience in the urban context of the city of Donostia-San Sebastian (Figure 1). The experience relies on active exploration of the city (streets, squares, churches, palaces, etc.), its people and their activities in order to have a better understanding and knowledge of the Cultural Heritage and collective memory of the city. The prototype includes location technologies that provide the location of each of the players in real time. Contents can be both streamed in real time over the infrastructure provided by the Public Administration within the "wireless cities" concept or downloaded to the mobile device of the player.

The experience is delivered through a serious game experience, allowing to capture and appeal a wide audience and to exploit specific educational and cognitive aspects of computer games. GeoJoko has been designed as a game structure which closely resembles a treasure hunt game. The participants are invited to go through a sequence of stages, which are PoI distributed in the city. At each stage, the player is presented with a stage-menu with some games based on multiple choice questions. Complexity of the games is based on the profile of the player. This is an appealing and funny typology, since players can discuss among a small number of possible answers, and favours reasoning modes based on exclusion and evaluation of possible alternatives.

Figure 1: *Overview of the GeoJoko prototype, including the location of the treasures, some of the contents displayed and screenshots of the application.*

Users make teams that move through the streets of Donostia-San Sebastián, discovering the uncovered treasures of the city. Several transport means can be used such as walking or ridding a segway. Treasures and the way of getting to them has been optimized taking into account such transport means. GeoJoko represents a new type of game, which uses wireless networks and ubiquitous computing technologies in order to interact seamlessly with the physical environment and the available multimedia contents.

The main target audiences are young adults aged 18 to 60 years. Nevertheless, the game has been designed for the general public, trying to reduce usability barriers at a minimum. Players are grouped in teams. The suggested team size is limited to two players, so that every person can actively participate in the game, in particular considering the limited screen size of palmtop computers.

The game does not impose time limits on user activities because it seeks to invite a leisurely journey of discovery and appreciation for the cultural heritage of the city. The winner is not the team which completes the path first, but the one which completes all the games best, gaining the highest score. Most games reward accuracy and effectiveness.

Two prototypes have been implemented within the GeoJoko project. The first one is a stand-alone prototype that is presented in this paper. A second prototype for mobile devices uses the existing wireless LAN in Donostia-San Sebastian city, which is owned by the Town Hall through Fomento de San Sebastian. GeoJoko implements new services over this infrastructure, providing new leisure experiences for the citizens and tourists. Moreover, the project analyses the viability and the business model of the so called wireless cities. The description and further evaluation of this prototype will be described in further papers.

Figure 2: *An example of the stage-menu, where the user is provided the question to find the treasure (The brother of your father is very old and has marvellous views to the bay).*

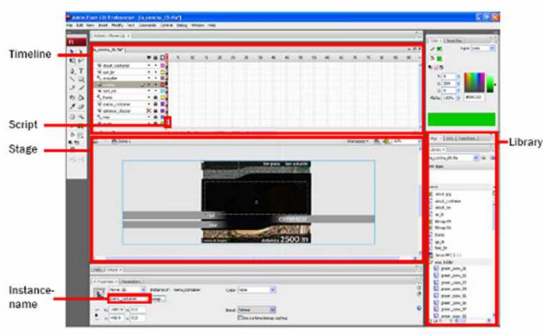

Figure 3: *Graphical Interface of the Flash programme.*

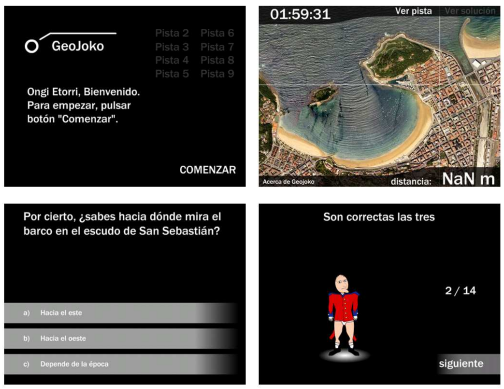

Figure 4: *Workflow of the GeoJoko project: (a) Welcome; (b) Location of the user; (c) Multiple choice questions for a stage; (d) Scoring system.*

The consortium of the project includes several SME and institutions that cover nearly the whole value chain, from the generation of contents related to Cultural Heritage and collective memory (Koma Zerbitzu Kulturalak), the provision of innovative wireless services (Cicerone), a final user such as Eventia Turismo y Publicidad, and a wireless infrastructure provider to design and implement new services for citizens (Fomento de San Sebastian).

4. Stand-alone prototype

4.1. Technical implementation

The development of the stand-alone prototype for PDAs is an application based on Flash that combines several technologies. Using the PlugIn Janus-Flash allows handling the GPS data from the mobile device in order to determine the position of the players.

Flash is an object-oriented programme based on a visual interface. The main components of the system are the scenario where the action takes place; the time-line that defines the events that take place in time; and the library with a list of clips and multimedia contents (Figure 3). The plot is written on keyframes over the time-line.

The workflow of the application is very simple (Figure 4). After welcoming the users, the position of the player is estimated on the basis of the GPS sensor of the mobile device and is graphically displayed on a map.

Once the user is near the location of the PoI associated to the corresponding stage, multimedia content is presented. This content is not executed on the Flash application, but on the Windows Media Player. When the multimedia has been visualized, the control of the workflow goes back to the Flash application. The system displays the question associated to the stage with the multiple possible solutions.

Regarding the stages, the system has a default time of eight seconds to allow solving the multiple choice question for the stage. This time gap has been tuned after several trials. Once the time is over, the system displays the correct answer to the question. Moreover, an estimated time frame has been defined to move from one stage to the following one.

4.2. Stages and associated contents

The stand-alone prototype is devoted to people that rent segways as a new way of moving through and discovering a city. The main target audiences are young adults, as it is the common range of ages of people who rent a segway. The first implementation of GeoJoko involved eight stages (Figure 5), including the following PoI: Alderdi Eder, La Perla, Pico del Loro, Peine del viento, Sculpture of the Queen, Cervantes square and Kursaal.

There were two main reasons for choosing the stages: follow the WiFi network coverage of the Donostia-San Sebastian Town Hall and follow the biking path of the city, as segways should take advantage of these lanes.

Figure 5: *Location of the stages for the first protoype surrounding the Bay of San Sebastian.*

In order to simplify and make the definition of the stages uniform, several characteristics have been defined for each stage, such as the title of the stage, its location (GPS coordinates), texts for the audio, text visualized on a mobile device and multimedia content associated to each stage. Moreover, additional information is provided in order to synchronize the audio, text and multimedia contents that are visualized on the screen.

The selection of the contents associated to each PoI have been conducted by curators and content creators. They combine current contents with historical pictures that represent some of the key memories of the city (Figure 6): the relationship of the queen Maria Cristina with the city, Chillidat's sculptures near the sea, the International Film Festival or the previous uses of the Town Hall as a casino.

Figure 6: *Some contents for the stand-alone prototype.*

4.3. Description of the experience

At the beginning of the experience, the mobile device displays the first stage and a map, where the current position and the distance to the target point are displayed (Figure 7). Players have to decide in which direction to move.

Figure 7: *Interface of the application to retrieve the solution of the stage.*

As a further information to solve the stage, the system displays the distance to the PoI in real time (Figure 8). Thus, players can change their direction in case the distance increases. However, if after some time the player does not know the solution to the stage, he/she can click on the display solution button in order to retrieve the location of the next PoI.

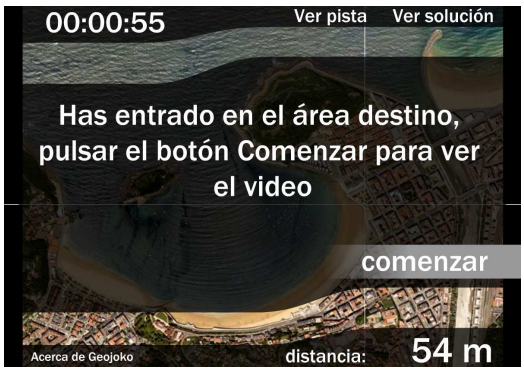

Figure 8: *Interface with the distance to the PoI once the user is the surrounding.*

When the player is near the target, an alarm is played and the player can visualize the multimedia content associated with the stage. The following screen displays the question

associated with the stage that should be answered in the correct way. If this happens, an avatar dressed on a traditional suit is displayed in order to present the scores. Further pieces of the traditional suit are added to the avatar if the answers were correct.

Once the stage is over, players receive additional information and the next stage is presented. The number of questions and further information is different on the basis of the PoI. A map is presented again and the estimated distance to the target.

Finally, after the last stage, players are guided back to the starting point of the experiences in order to know their answering skills. Depending on the points rewarded, the avatar will be more or less dressed (Figure 9). If players reach almost the maximum amount of points, the character becomes a director that sets the flag of the city and some traditional music of San Sebastian can be heard.

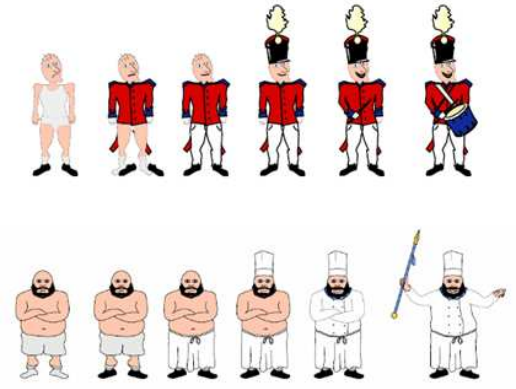

Figure 9: *Final options for the scoring system.*

5. Evaluation of the stand-alone prototype

Several field tests have been conducted with players during the early phases of the project that several critical features regarding usability and user-friendliness could be improved. An evaluation campaign conducted in late October 2008 assessed the impact of GeoJoko on users of a segway tour and checked its suitability as an edutainment tool for discovering a city.

5.1. Description of the evaluation experience

After a brief introduction about the performance of the segway, players collected a PDA with the GeoJoko software already loaded. Although the game can be installed in the PDA of the players, we have followed this approach for the validation of the prototype. Given the wide variation in technical specifications and characteristics of current mobile devices, the consortium provided a standard reference device to team of players for the evaluation.

The selected device should satisfy the following technical requirements: 600 MHz processor, 128 MB RAM memory, Windows Mobile V5.0/6.0, GPS sensor and WiFi connectivity (Figure 10). The HP iPAQ 214 was selected for the experience as it fulfils all the requirements except the GPS sensor. Thus, an external GPS was connected using the Bluetooth connectivity o the device.

Figure 10: *Mobile devices used for the evaluation of the stand-alone prototype.*

After a brief general introduction to GeoJoko by the owners of the segways, each couple of players received a compact GeoJoko device. The explanation included a brief description of the project, its objectives and partners.

5.2. Evaluation methodology and results

The acceptability of the general approach of the GeoJoko project, the fulfilment of the objectives and the interaction metaphor have been identified as key parameters as measurement of the overall system performance from the point of view of the player. The validation parameters were divided into four major sections, which tried to assess the following aspects:

- Usefulness. This parameter measures the system efficiency in terms of the goals achievement of the objectives. Therefore, positive feedback provides the best proof of achieved quality in the implementation of the prototype on the one hand, and a satisfactory achievement of the initial approach of the project on the other hand.
- Easy to use. The object of validation is the performance of the game from the point of view of the player. This parameter measures the easiness of the system to accomplish the user required tasks. The use of the system should

not depend on the knowledge of the internal structure and architecture of the game.
- Usability. Closely related to the previous parameter is the usability of the game. A usable system is easy to use. However, while the previous parameter is more related to the purpose addressed by GeoJoko, such as the way the game fulfils tasks, usability deals with the impact of the user interfaces on the acceptance of the user.
- Marketability. It is obvious that product marketability is more properly addressed by SWOT Analysis and Exploitation and Business Plans. What was analysed by the questionnaire was the general idea of acceptability of such a system for the ordinary player that took part in the event.

A questionnaire was used to perform a qualitative analysis of user acceptance and satisfaction in authentic use conditions (Figure 11). This questionnaire contains 23 multiple choice questions and a free comment section.

Figure 11: *Users during the evaluation.*

The validation of the prototype took place between the 22nd of September 2008 and 5th October 2008. The experiment involved 19 participants in several sessions. 7 female and 12 male participants took part in the assessment, with an average age of 16-30 years. Most of the users were citizens of Donostia-San Sebastian, while there were also players coming from the nearby provinces (Alava, Bizkaia) and other regions and countries (Germany, France, Colombia, Slovakia).

To cover all eight stages of the first stand-alone prototype riding a segway, the game sessions ranged from one hour and a half to more than two hours. When the experience ended, participants were asked to fulfil a questionnaire and also interviewed informally about their experiences by members of the consortium.

The quantitative evaluation has been based on the results of 19 questionnaires. All the questionnaires have been presented and distributed in printed copies. Once all the data have been collected, they have been processed by statistical analysis tools and then data mining has been performed.

The evaluation has been successful and valuable information for further developments of the prototype has been collected. Although the overall impression about the prototype was positive, the following comments should be mentioned:

- **How did you know about GeoJoko**. Two third of the players knew about GeoJoko by the partners of the consortium. Our analysis reveals that user familiarity with new technologies has little correlation with the considered variables, suggesting the suitability of GeoJoko as a tool for the general public. Over 20 per cent of the users use normally computers, laptops, mobile telephones and Internet. Finally, the main motivations for using GeoJoko have been to enhance the knowledge of the players about the city (more than 60 per cent) and to enjoy the visit to the city as it was free (nearly 25 per cent).
- **What did you think about the stages**. The game invites players to go through a sequence of stages that showcase Points of Interest (churches, palaces and squares) distributed through the city. Most of the users were very satisfied with the stages although a quarter of the respondents found it too long. Moreover, the number of stages for the prototype was also considered as correct by three quarters of the players. The optimum number of stages for most of the users was among 7 and 8, so the current number was appropriate for the 58 per cent of the users. Regarding the complexity of the quizzes and questions associated to the stages, the answers were very different from each other. Although some of the players found the questions very difficult (32 per cent), the level of difficulty was appropriate for the same percentage.
- **Assessment of the multimedia content**. Nearly three quarters of the players were satisfied with the quantity of the available information and content. Only 10 per cent affirmed that there was too much information in each of the stages. A further question tried to measure the quality of the information. 70 per cent of the users affirmed that the available content was quite interesting. Moreover, the user friendliness and attraction of the game was also evaluated. Two thirds of the players agreed with this statement.
- **Assessment of the technical quality**. One of the main aspects is the speed for visualizing the multimedia content as the basis for the acceptance of the application. 68 per cent of the players agreed on the correct rendering speed for the multimedia content. 60 per cent of the respondents complained about the quality of the audio due to teh en-

vironmental noise. Regarding the interface, more than 90 per cent of the players was very satisfied with the user-friendliness of the Graphical User Interface of GeoJoko, so they did not recommend any changes.

- **Assessment of the experience**. Regarding the functionalities provided by GeoJoko, most of the users (60 per cent) affirmed that the most attractive feature of the prototype was the new way of learning more about the city in an engaging way. 25 per cent of the users mentioned the possibility of displaying the current location on a map. Other aspects such as the dynamics of the game or the use of the technology as a tool to improve the experience were also well assessed.
- **Commercial exploitation**. 95 per cent of the users answered that they would use GeoJoko again. Regarding the most appropriate device for the experience, 60 per cent of the players selected the PDA while 30 per cent chose a mobile telephone. 80 per cent of the users answered that they would pay for the experience. Regarding the price, most of the users (42 per cent) would pay between one and three euros, and 26 per cent of them between 4 and 6 euros.

6. Conclusions

This paper describes the results of the evaluation of the stand-alone prototype of the GeoJoko project. The project explores new ways in which technology can provide people with rich and engaging digital experiences as they move through physical spaces, including historical experiences, performances and games.

It is an example of an innovative approach to location-based serious games that use wireless and ubiquitous computing technologies to create a linkage between the physical Heritage and new technologies. The project focuses on investigating how a computer game can improve the understanding of the Cultural Heritage and collective memory of the territory.

The project is based on a game structure that closely resembles a treasure hunt. Instead of finding treasures, GeoJoko aims at finding the right route to a given Point of Interest when visiting a city. Passing from one stage to the next is a critical aspect of the game. In the typical treasure hunt, players make this transition by solving an enigma. In this case, when the user is at a given location, he/she is provided with some kind of quiz in order to find the next stage. While following a path, players can check the map to determine their current position and desired direction.

Two prototypes have been implemented within the GeoJoko project. The first one is a stand-alone prototype that is presented in this paper. A second prototype for mobile devices uses the existing wireless LAN in Donostia-San Sebastian city, which is owned by the Town Hall through Fomento de San Sebastian. The description and further evaluation of this prototype will be described in further papers.

This paper has presented the technical description of the stand-alone prototype. The development of the stand-alone prototype for PDAs is an application based on Flash technologies that combines several technologies. The first implementation of GeoJoko involved eight stages. The selection of the contents associated to each PoI have been conducted by curators and content creators. They combine current contents with historical pictures that represent some of the key memories of the city.

Moreover, the evaluation has been successful and valuable information for further developments of the prototype has been collected. Most of the users were very satisfied with the stages although a quarter of the respondents found it too long. Regarding the complexity of the quizzes and questions associated to the stages, the answers were very different from each other. Finally, most of the respondents answered that they would pay for the experience between one and three euros.

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