ATAS DO

4º encontro sobre jogos e mobile learning

2018

FICHA TÉCNICA

Atas do 4.º Encontro sobre Jogos e Mobile Learning

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NOTA DE ABERTURA

O 4º Encontro sobre Jogos e Mobile Learning é um congresso internacional, organizado na Faculdade de Psicologia e de Ciências da Educação, no âmbito das atividades do LabTE da Universidade de Coimbra e em coorganização com a Universidade de Sevilha. O EJML'2018 reflete a emergência de novos paradigmas educacionais, influenciados pelos desenvolvimentos das tecnologias digitais e dos jogos educacionais, bem como pelos desafios colocados à sua integração no processo educativo.

Por intermédio das tecnologias digitais e da inovação muitas áreas da sociedade estão a encontrar novas formas de resolver os seus problemas. Neste sentido, a Escola não pode alhear-se das mudanças que ocorrem na sociedade, devendo contribuir para melhor preparar os alunos para os desafios do futuro. Os dispositivos móveis e os jogos fazem parte da vida dos alunos, por isso, é essencial encontrar formas de os integrar como ferramentas de aprendizagem. A aula deve deixar de ser um espaço fechado para se abrir ao mundo e à inovação. Nesta edição, criamos a possibilidade dos profissionais de ensino poderem reportar o que têm estado a fazer, desafiando-os para o Relato de Experiências.

Investigadores e professores partilham as suas reflexões e contributos, discutindo as mais recentes metodologias e inovações tecnológicas e apontam caminhos de desenvolvimento futuro no domínio da educação e da formação.

As atas integram as conferências, as três intervenções no painel, comunicações breves, comunicações longas, relatos de experiências e os tutoriais dos workshops dinamizados no congresso. Os textos publicados, depois de submetidos a um processo de "blind review", refletem trabalhos desenvolvidos em Portugal, no Brasil e em Espanha.

Para quem se interessa pelas questões da educação, encontra nestas Atas do 4º Encontro sobre Jogos e Mobile Learning o reflexo do panorama nacional e internacional.

A Comissão Organizadora

The EduPARK game-like app with Augmented Reality for mobile learning in an urban park

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Abstract – Mobile devices are pervasive and can be used to promote learning in a contextual way. When combined with innovative technologies, such as augmented reality (AR), and game-based approaches, mobile devices can boost engagement with learning.

Giving continuity to previous work, this paper presents the EduPARK game-like application (app) that is an interactive, interdisciplinary quiz with AR, based in Geocaching principles, intended to be played in a specific urban park. Furthermore, this app was developed through a design-based research methodology with four cycles of development involving user testing and evaluation. Several field tests were conducted, involving different convenience samples of potential users, from basic to higher education, including pre and in-service teacher training and lifelong learning (park visitors). The app was progressively refined according to the users' feedback in each cycle, concerning usability and educational value.

This contribution comprises an example of how to develop successfully learning opportunities based on mobile games with AR technology that may be relevant to educational game designers and educators. Future work involves the organization of regular activities for students, teacher trainees and tourists to collect data in order to analyse the processes of mobile learning in outdoor settings, namely in articulation with curricular contents.

Keywords: outdoor mobile learning, game-based learning, augmented reality, urban park

Introduction

The pervasiveness of mobile devices in modern societies makes them valuable resources to promote contextual or situated learning (Parsons, 2014). When combined with augmented reality (AR) and game-based learning (GBL), mobile devices can also promote engagement with learning (Giannakas,

Kambourakis, Papasalouros, & Gritzalis, 2017). Taking that into account, the EduPARK project[45] aims to promote interdisciplinary learning with games using mobile devices, AR and Geocaching in outdoor settings, such as urban parks. The project has just created an interactive AR game-like application (app) that comprises a set of educational guides with several curriculum-articulated subjects for teachers and students from basic to higher education in Portugal, and also for the general public. This will move students out of the traditional learning sets to outdoor environments, surrounding their schools, where they can see, observe, search, touch and understand contents they usually explore only through school textbooks.

The current account gives continuity to previous work under the EduPARK project (Pombo, Marques, Carlos, et al., 2017; Pombo & Marques, 2017; Pombo, Marques, Afonso, Dias, & Madeira, n.d.; Rodrigues, Carvalho, Pombo & Neto, 2017) by presenting the final version of the EduPARK app with open access to the public. It was developed through a design-based research methodology, with four cycles of development that included user testing and evaluation, concerning the app's usability and educational value.

The next sections briefly present and discuss: i) the project's theoretical context concerning m-learning, AR and digital games in Education; ii) the aims of this paper; iii) the project's design-based research; iv) the development of the EduPARK app and its final version; and v) this work main conclusions.

Theoretical context

According to Crompton (2013), mobile learning denotes a way of learning across contexts, through social and content interactions, with the support of mobile devices. Among their affordances are the mobility (Parsons, 2014); the instant access to learning content (Giannakas et al., 2017); and the hardware and applications' panoply that support orientation, measuring, registering, organising and communicating, among other activities, enhancing contextual and situated learning (Parsons, 2014). Regarding its pitfalls, the literature mentions it entrenches digital divides regarding technology access, technological skills and learning competencies (Parsons, 2014).

GBL refers to using games to enhance knowledge and skills acquisition, whilst providing players/learners with a sense of achievement (Qian & Clark, 2016). Games are pointed as potentially powerful learning environments as they may activate prior knowledge and afford immediate feedback, among other advantages (Ketelhut & Schifter, 2011). However, GBL require careful design to balance the play and the learning outcomes (Giannakas et al., 2017). Combining m-learning and GBL may result in increased motivation, self-directedness, and social and inquiry skills (Giannakas et al., 2017).

As to AR, it has been defined as a technology that allows overlapping virtual elements (e.g., 3D models) with the physical environment, in real-time, producing a new experience (Azuma et al., 2001; Dunleavy & Dede, 2014). The virtual objects can be triggered by image recognition, in image-based

[45] Mobile Learning, Augmented Reality and Geocaching in Science Education – an innovator design-based research project (http://edupark.web.ua.pt)

AR, or by the user's location (from GPS or wireless network), in location-based AR. Image-based AR can use marker-based tracking, requiring 2D labels, or markerless-based tracking, with the recognition of real environment images (Koutromanos & Avraamidou, 2014). Nowadays, the dissemination of mobile devices allows the public to have access to AR systems. Regarding AR advantages in education, a literature review (Akçayır & Akçayır, 2017) highlights that it can make boring content more enjoyable, provide immediate feedback and support autonomous learning and, thus, it has potential to increase learning performance (Akçayır & Akçayır, 2017; Radu, 2012). However, its usability may be one of the most reported challenges, hence, AR experiences need to be well designed to guide the students. In addition, technical problems, in particular with GPS, are common (Akçayır & Akçayır, 2017) because the app can misperceive a location and/or direction.

Aims of this work

As there are evidences of benefits of mobile GBL with AR for Education, namely in what concerns intrinsic motivation, learning outcomes and skills development, the main aim of this particular paper is to describe the development process of the EduPARK app, highlighting the importance given to the user experience in the app's evaluation in what concerns its usability and learning value. This app's relevance relies in:

a) the fact that it includes an interdisciplinary game integrated in the National Curriculum;
b) its AR contents, which were developed specifically for this purpose, and support situated and authentic learning in an outdoor environment, moving learning out of the traditional classroom settings;
c) its accessibility and mobility, as it is supported by mobile technologies already available to many western societies students (Mascheroni & Cuman, 2014);
d) its high usability and learning value, recognized by the users, as it will be analysed in the following sections.

Methodology

The EduPARK project follows a qualitative interpretative methodology (Amado, 2014) fitting in a design-based research (Parker, 2011), as it provides a useful framework for developing technology-enhanced learning environments comprising various cycles of refinement of the prototype: a game-like app for mobile devices with AR under Geocaching principles (Figure 1).

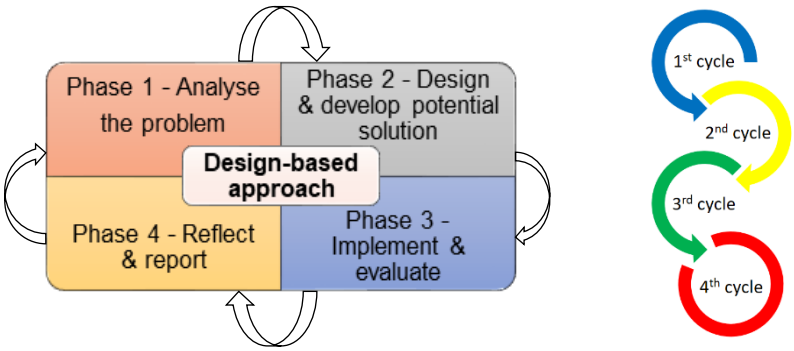

Figure 1. EduPARK project methodology: design-based research (Parker, 2011) with four refinement cycles

Context

The 1st cycle of app development started with the problem analysis regarding three relevant areas: educational purpose, content, and technology.

The Portuguese National Education Curriculum Directives, from Basic Education (BE) to Higher Education, were analysed to identify multidisciplinary issues (e.g., integrating Biology and History) to be explored in an urban park. The aim was to identify learning opportunities to explore in four educational guides aligned with the Curriculum for different audiences: 1st cycle of BE (aged 6-9); 2nd and 3rd cycles of BE (aged 10-14); Secondary Education (SE) and Higher Education (HE); and Park's visitors, as the app also targets the general public. In this case, the guide for tourists is available in Portuguese and in English.

The selected outdoor environment for the exploration of the EduPARK app is an urban park situated in Aveiro (Portugal), the 'Infante D. Pedro Park'. This Park is a large green area, with exotic and native botanic species, avifauna, a lake and several historical points of interest; therefore, it has a high potential for educational purposes. The project's mascot, a female monkey, was inspired in the Park's informal name, 'The Monkey Park', which was due to a female monkey that lived in the park some decades ago.

During the development of the app and for the activities with the public, a set of Android smartphones were used; as the app was developed under this operating system, using the cross-platform game engine Unity 5. For AR technology, both image-based and location-based were considered. For marker-based tracking, the platform Vuforia SDK for Unity was explored, and the tracking system of the location-based AR involved the GPS.

The refinement cycles

Following the problem analysis phase, each refinement cycle included:

a) the app and guides creation/refinement (phase 2 of the design-based approach);
b) field tests with users and data collection and analysis (phase 3);
c) results reflection and report (phase 4).

Each cycle is briefly explained in the Results section. Details were described in previous work (Pombo, Marques, Carlos, et al., 2017; Pombo et al., n.d.; Pombo, Marques, Loureiro, et al., 2017).

Data collection and analysis

To allow data triangulation (Amado, 2014), a set of techniques and instruments were used, according to the Table 1.

Data collection instrument	Moment of use	Type of data collected	Data analysis techniques
observation protocol, described in Pombo, Marques, Carlos, et al. (2017)	during the tests	players' behaviour and perceptions; critical incidents' descriptions	content analysis with categories emerged from the empirical data
focus group interview, described in Pombo, Marques, Carlos, et al. (2017) and in Pombo et al. (n.d.)	end of the tests	players' perspectives about their enjoyment, easiness, experience and improvement suggestions regarding the app and activity	content analysis with categories emerged from the empirical data
individual questionnaire, described in Pombo et al. (n.d.)	end of the tests	players' profile and their perceived usability of the app	descriptive statistics analysis; to compute a System Usability Scale (SUS) score (Brooke, 1996; Martins, Rosa, Queirós, Silva, & Rocha, 2015)
app logging mechanisms described in Pombo et al. (n.d.)	during the tests	app's usage data, such as scores, number of correct and wrong answers or game time	descriptive statistics analysis

Table 1. Synthesis of the data collection and analysis

The tests were conducted, frequently in outreach activities of the EduPARK project's host institution, the University of Aveiro (UA), so players' samples were convenience samples, according to the enrolments in those activities; and for motivation purposes, the app was not played individually but by groups of players, allowing a friendly competition.

Results

This section is divided in two parts: one describing the development of the EduPARK app, and the second presenting the app itself.

The EduPARK app development

1st refinement cycle

The app's prototype comprised a quiz with multiple-choice questions and content (text, audio or image), feedback to the players' answers and score keeping. Additionally, the game prompted the player(s) to go to specific Park locations and find temporary markers or physical *caches* with markers. Markers functioned as checkpoints of localization in the Park, for progress in the game. The prototype included two guides, for the 1st and for the 2nd/3rd cycles of BE both including interdisciplinary questions based in the curriculum, requiring observation in the Park (e.g., botanical specimens).

Under the 2016 UA Open Week of Science and Technology, 74 students explored this prototype in the Park using the project's smartphones. Those students belong to 2 classes of the 4th school level (aged 9-10) and to one class of the 8th school level (aged 13-14). Students reported they enjoyed the app and acknowledged its value for authentic learning: 'I think that what is funnier is the fact that the app involves nature and walking in the Park' (8th school level student). The prototype reached an average of 85.6 in the SUS scale (Brooke, 1996; Martins et al., 2015). Nevertheless, some difficulties were pointed out, namely in the markers' recognition (Pombo et al., 2017; Pombo, Marques, Afonso, Dias, & Madeira, n.d.).

2nd refinement cycle

The students' feedback was used to refine the app and the educational guides. The most relevant improvements included more reliable markers and AR contents. Markerless tracking was also implemented, using decorative tiles already installed in the Park.

The new EduPARK app was tested by 23 secondary students (aged 15-19), under the 2017 UA Open Campus, and 21 young pupils (aged 9-10), under the collaboration of two projects within the Masters Degree in Education. Once more, the students reported a positive perception of the app value for learning: 'I would like to play the game again because it was really fun to use cell phone in a lesson to review the content we learnt' (4th school level student). This app version reached an average of 86.2 in the SUS scale. Students proposed some improvement suggestions, such as to include riddles to unlock treasure chests.

3rd refinement cycle

The app's main new features were the inclusion of audios, videos and animations; GPS based search for virtual *caches* (treasure chests), containing virtual objects, and prompted by riddles. A new guide for the 2nd cycle of BE was designed to be tested under the 2017 Summer Academy by 24 students (aged 10-12), who reported that the use of the app increased their motivation to learn: 'We feel more motivated to do the calculus of an area in real life. It has a real purpose' (2nd school level student). This app version reached an average SUS score of 85.8. Nevertheless, the GPS virtual *caches* were

problematic, as the GPS signal was unreliable with dense tree crowns: 'Sometimes, the information of the distance to the virtual *cache* didn't work very well.' (6th school level student).

4th refinement cycle

The guide for the SE/HE was developed and the search for *caches* was based in riddles to find a specific marker, instead of using GPS. The change in the AR triggering thecnology is due to the frequently reported GPS precision errors, both in the literature (Akçayır & Akçayır, 2017) and in previous app refinement cycles. Addittionally, 32 permanent plaques of botanic specimens identification, with AR markers, were installed to allow autonomous exploration of the app by users, without the project's support, as proposed in Pombo and Marques (2017).

Under the curricular unit 'Nature Integrated Sciences', 46 Basic Education Graduation students, future-teachers, explored and tested the app. For the first time, it was tested with the users' own mobile devices (instead of the project's smartphones), which involved a wide typology of devices and created more technical problems. E.g., one student said 'The app is heavy [in terms of storage space in the device], which makes the phone to crash sometimes.' Nevertheless, overall, the educational value of the app was acknowledged: 'I think the app was really good to recall some knowledge and, also, to learn new one.' This app version reached an average of 70,9 of SUS score, which was the lower in all tests. This may be explained by two factors:

1) the users were older (future educational professionals) and maybe were more critical than the younger children that had tested the app until this moment; this is not a new result, as the literature has had found that SUS scores tend to decrease with increasing age (Bangor, Kortum, & Miller, 2009); and
2) the diversity of cell phones used in this test turn it more challenging, from the technological point of view.

Students made improvement suggestions both at technological and educational levels. E.g., one mentioned 'The path in the Park should be always in one direction, instead of going back and forward.' This feedback was considered in the last refinement of the app and guides, resulting in the EduPARK app released to the public, freely available in the Google Store (http://edupark.web.ua.pt/app). This final version is described in the next section.

The EduPARK app

After the installation of the EduPARK app in the device, it prompts the user to update the quizzes (games) and further use does not require internet connection. In the initial exploitation of the app (Figure), the user can:

a) select the desired language, Portuguese or English;

b) fill in a profile for the player or team of players;

c) select one of the available modes: the 'game' mode and the 'explore freely' mode. Both modes include AR contents.

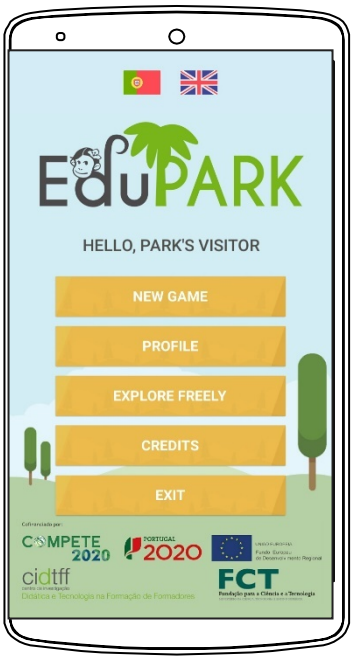

Figure 2. Initial screen of the EduPARK app, with the language options, profile and different modes of app use

In the game mode, the player or group of players is/are prompt to select a guide, accordingly to his/her/their profile: level of formal or informal learning. Each guide includes a different set of multiple-choice questions, *caches* and path through the Park. Afterwards, the player(s) is/are welcomed by the project's mascot that briefly explains the game structure, main aim of accumulate points by answering correctly the questions, among other relevant features. The game is divided in four phases, each one corresponding to a path with multiple-choice questions (Figure), to be answered whilst the player(s) is/are in a specific zone of the Park, according to the app's map (Figure). To better support the player(s) orientation in the Park, the app also includes a compass tool. Moreover, the project's mascot supports the player(s) along the game by giving:

a) guidance about the path in the Park;
b) educational content relevant for question answering (images, audios, videos, including information augmenting the reality);
c) feedback to the answers.

The project's mascot also supports the player(s) in the game through a tutorial that is triggered the first time a new game feature is used, such as the map or the AR markers detection.

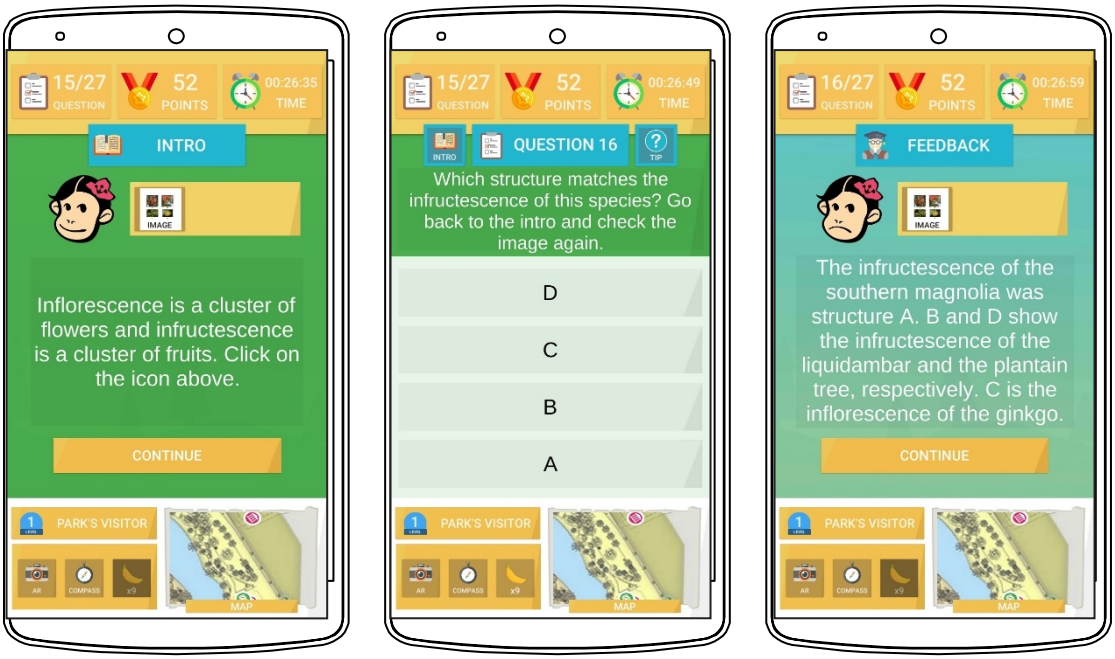

Figure 3. Example of a multiple-choice question and respective feedback

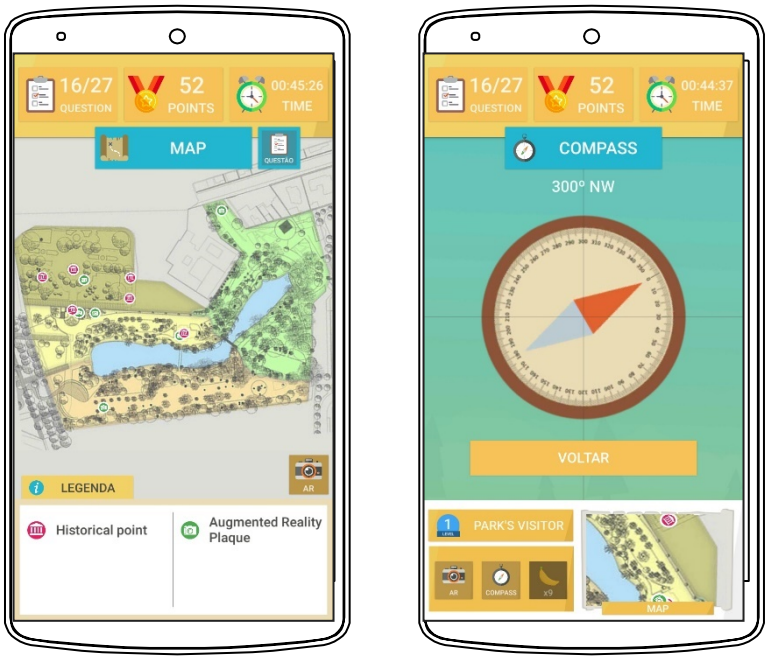

Figure 4. The map of the Park, divided in four zones and revealing relevant localization, and the compass tool

As mentioned before, the app prompts the player(s) to search for AR markers in the Park that will deliver information for answering specific quiz questions (Figure) before they are shown.

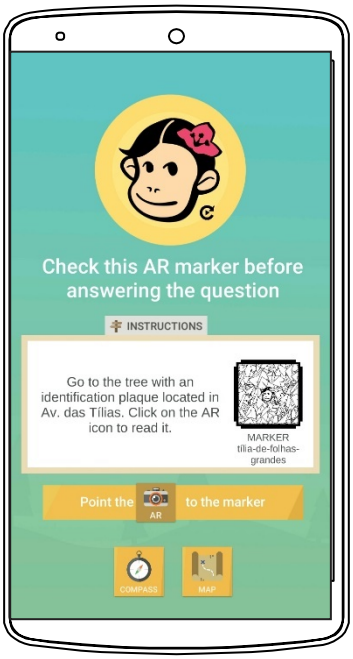

Figure 5. Example of instructions to find an AR marker

Markers are printed in permanent plaques (Figure) at specific locations, to allow autonomous exploration of the app. The plaques are next to botanic specimens of different species, selected as representative of the Park's biological richness. Their installation was proposed to the Aveiro's Municipality, planned and funded by the EduPARK project and they have a double purpose:

a) AR trigger with the use of a mobile device; and
b) identification of 32 botanic species without the use of such devices (Pombo & Marques, 2017).

Figure 6. Example of a plaque with an AR marker, next to a botanic specimen, and AR marker detection

All plaques have the same layout; however, the information in each one varies accordingly with the botanic specimen: the scientific and common names, its family (in biological classification), its origin and the AR marker, with the project's mascot (Pombo & Marques, 2017). The AR content associated with each plaque includes resources about the identified species (texts, photos, videos, 3D models), as illustrated in Figure.

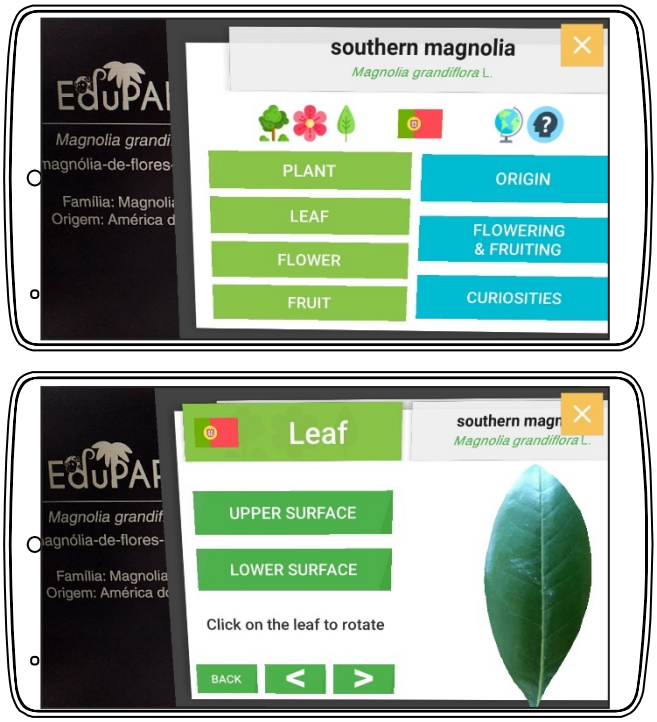

Figure 7. Example of botanic AR content

The app also includes AR markerless tracking, increasing the number of opportunities of situated and authentic learning in the Park (Figure).

Figure 8. Example of a markerless AR tracking in the Park

At the end of each phase, the player(s) receive a clue to a virtual *cache* (Figure). If found, it awards points and virtual objects that can be trade for help with the questions.

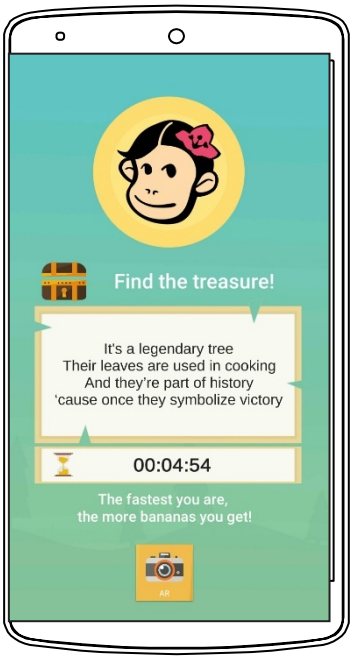

Figure 9. Example of a riddle to find a virtual *cache*

At the end of the game, the app shows the main data about the game, such as the score or the time on game (Figure). For the same profile, it is possible to know the historical information about the reached level, completed games, percentage of questions answered correctly, number of markers visited and number of *caches* found.

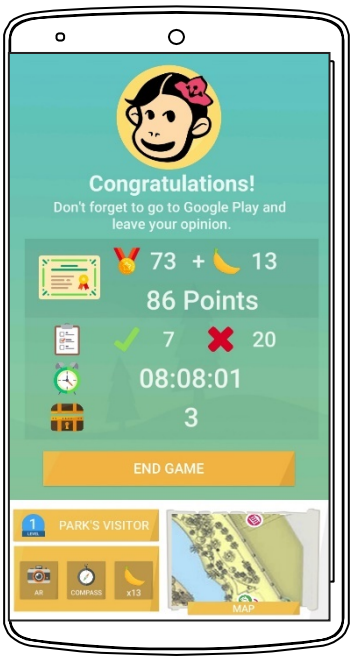

Figure 10. Data displayed on screen at the end of a game

Additionally, the app has an 'explore freely' mode. This allows user(s) to access AR content from the markers and from the markerless locations, without having to play the game.

Conclusions

The EduPARK project followed a design-based research methodology, with four refinement cycles, to create a game-like app integrating interactive and interdisciplinary quizzes with AR contents associated, based in Geocaching principles, to be explored in an urban park. The app includes four educational guides for different audiences, from basic to higher education and also for tourists. In each refinement cycle, samples of potential players tested the app in the Park and their feedback was used to refine it in the following refinement cycle, as well as the educational guides which are integrated in the app. This methodology revealed to be successful in developing a mobile game-like app with AR contents in what concerns its learning value, according to the users' feedback. Furthermore, the app reached high SUS scores (Bangor, Kortum & Miller, 2009) revealing its high level of usability.

Future work involves organizing regular activities for students, teachers and the general public. It is also predicted to conceive several teacher training sessions to collected systematic data about the benefits of using this mobile learning strategy in outdoor settings.

The main relevance of the EduPARK project is the articulation between research and development, professional practices, and initial and advanced training, as well as its innovation concerning outdoor learning strategies, in formal, informal, and non-formal contexts. This research also prompts to capitalize urban spaces' educational value, in association with the City Council.

The EduPARK app is a resource with potential impact in schools, local community and also in the tourism sector.

This particular work, which described the four cycles of refinement of the EduPARK app is useful for educational technology developers and researchers, who may build work from the one presented here, and for educators, who can learn about the potential of mobile game based learning, with AR in outdoor settings.

Acknowledgment

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