Evaluation of a Mobile Augmented Reality Game Application as an Outdoor Learning Tool

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ABSTRACT
There is a discussion on the potential of augmented reality (AR), mobile technologies to enhance learning. This article presents: 1) the EduPARK project’s first cycle of design-based research for the development of a mobile AR game-like app that aims to promote learning in an urban park, and 2) an experience of students using it in loco. The focus is the students’ perceptions regarding the usability and functionality of the app. Data collection involved focus groups, questionnaires and app usage information. Data was submitted to content analysis and descriptive statistics. Results revealed an excellent usability of the EduPARK app, with an average system usability scale of 85.6. Overall, students reported that the app was enjoyable, easy to use and promoted learning; however, improvements and more evaluation experiences are needed to better understand mobile AR game-like learning in urban parks.

KEYWORDS
Augmented Reality, Design-Based Research, Educational Game, Mobile Learning, Outdoor Learning, User’s Evaluation

INTRODUCTION
Mobile devices are owned by an increasing percentage of students (Chen, Seilhamer, Bennett, & Bauer, 2015; Sozio et al., 2015), so educators can take advantage from their pervasiveness, as they can be used to promote learning anytime/anywhere. One of the arguments for mobile devices’ educational use is that their affordances have been empirically established, both for learning achievement and for students’ affective learning outcomes, such as attitude, motivation or engagement (Sung, Chang, & Liu, 2016). Moreover, mobile devices can also support emerging technologies, such as augmented reality (AR), and, when combined with educational games, they can also promote student engagement for deeper and authentic learning (Huizenga, Admiraal, Akkerman, & Dam, 2009).

The literature suggests there is no limit to the potential valuable educational uses of AR applications (Chang, Morreale, & Medicherla, 2010) that are aligned with situated (FitzGerald et al., 2013) and constructivist learning theories (Dunleavy & Dede, 2014). On the one hand, situated learning highlights the relevance of social interactions among people, for learning within a specific

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context. On the other hand, constructivist theory emphasizes the impact of the individuals’ previous knowledge in the learning processes (idem, ibidem). For students to develop essential 21st century skills, such as problem solving, collaboration, digital and communication proficiency, more active and authentic learning methods, both inside and outside the classroom, are needed (Johnson et al., 2016). The development of those competences requires learners to take the responsibility for their learning and become engaged participants, rather than passive observers (Pombo et al., 2011).

The EduPARK project intends to combine mobile AR technology with outdoor gaming strategies, based on geocaching principles, to enhance student motivation and allow learning to move beyond traditional classrooms to natural spaces. Such outdoor settings allow students to explore nature while making connections with curricular content in a collaborative way. With that aim, one of the main outcomes of this project is a user-friendly mobile AR game app, enabling students, teachers and the public to explore and access interdisciplinary information while visiting a green park in Aveiro (Portugal), the Infante D. Pedro Park. This park serves as the “lungs of the city”, presents a rich botanical diversity and historical patrimony and includes several curriculum-articulated learning opportunities (Pombo et al., 2017). The app comprises educational guides, in accordance with the Portuguese National Education Curriculum, with questions, challenges, enigmas, and problems using pathway orientation, so that students and park visitors can enjoy a pleasant walk while learning.

Urban green parks frequently attract a large number of students and teachers, as well as regular local visitors and a wide range of tourists (Ballantyne, Packer, & Hughes, 2008). Such pleasant environments have the potential to provide learning experiences about the importance of plants, habitats and their conservation, and may also influence the values, attitudes and actions of their visitors (Willison, 1997). The use of new interactive technologies in outdoor settings may provide an opportunity for students to be physically engaged in task solving (Bacca, Baldiris, Fabregat, Graf, & Kinshuk, 2014), participate in non-sedentary activities, experience biodiversity in Nature and value the protection of green spaces. This promotes an active participation of students, constructing their knowledge, as well as the development of values enhancing an authentic learning (Herrington & Parker, 2013). Several authors (Chang et al., 2010; Lee, 2012) emphasise that AR has the potential to foster learners’ motivation and engagement in applying and discovering resources in the real world from a variety of perspectives. However, as the use of mobile AR technology is relatively new, there is little research in this area, particularly with the aim of promoting learning in the outdoors (FitzGerald et al., 2013). The exploration of this technology for educational purposes in the outdoors is new; hence, the novelty of the EduPARK project.

The main purpose of this paper is to present the EduPARK project’s first cycle of design-based research to develop a prototype of a mobile AR game app that aims to promote learning in an urban green park. After the prototype development, 74 students (9/10 years-old and 13-14 years-old) used it in loco and evaluated it. The evaluation sessions aimed to collect students’ perceptions regarding the app usability, their acceptance of the app and improvement suggestions, as well as some data of students’ performance using the app to analyse learning promotion. The evaluation results are analysed with the aim of identifying features to improve in further versions of the app during subsequent cycles of this design-based research, until a stable, user-friendly and reliable app version is reached. Additionally, design guidelines for the development of mobile AR game app interdisciplinary outdoor learning are proposed.

The paper is structured in the following sections: (1) literature review on mobile AR and its relevance in education contexts; (2) research approach, explaining the first cycle of the design-based methodology, including a description of the app, data collection (with a questionnaire, focus groups, and the app usage data), and data analysis (descriptive statistics, computing of the System Usability Scale (SUS) score and content analysis); (3) main results presentation and discussion; and (4) conclusion, with the final remarks, design guidelines and recommendations for future work.
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