Augmented reality and pedestrian navigation through its implementation in m-learning and e-learning: Evaluation of an educational program in Chile

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ABSTRACT

The implementation of Mobile Pedestrian Navigation and Augmented Reality in mobile learning contexts shows new forms of interaction when students are taught by means of learning activities in formal settings. This research presents the educational, quantitative, and qualitative evaluation of an Augmented Reality and Mobile Pedestrian Navigation app. The software was designed for mobile learning in an educational context, to evaluate its effectiveness when applied as a teaching tool, in comparison to similar tools such as those present in e-learning. A mixed-method analysis was used, with primary school students from Chile as subjects (n = 143). They were split into one control group and one experimental group. The control group worked in an e-learning environment, while the experimental group performed the activity as field work, making use of the app (m-learning). Students were evaluated pretest and posttest using an objective test to measure their level of learning. In parallel, a satisfaction survey was carried out concerning the use of these technologies, in addition to interviews with several students and teachers of the experimental group. Pretest-posttest results indicate that the experimental group outperformed the control group in their learning levels. The results of the interviews and the satisfaction survey show that these technologies, combined with fieldwork, increase the effectiveness of the teaching-learning processes. Further, they promote the interaction of students with contents for learning, and they improve students' performance in the educational process. The main goal is to provide a methodology for the analysis of an ad-hoc designed app. The app is intended to provide an m-learning process for subjects being taught about cultural heritage. The quantitative and qualitative results obtained show that it can be more effective than using similar technologies in e-learning contexts.

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1. Introduction

The ever-growing use of ICT has produced a new scenario that is affecting one of the most important elements in the development of any society: comprehension, analysis and visualization of the territory. This new scenario of work with digital and computer media, ranges from the simple representation or modelling of spatial scenarios, to the possibility of generating and structuring places from new and complex data structures (Virtual Reality). This has become possible with the development of extremely powerful processing techniques and methodologies for graphical display.

These developments have not remained outside the field of education; rather, they have influenced education very strongly through the creation of new dissemination tools, and of new knowledge creation and learning structures. In particular, new ideas and lines of action have been implemented that are related to the various types of established technologies, such as Mobile Learning (m-learning) and Ubiquitous Learning (u-learning) (Crompton, Burke, Gregory, & Gräbe, 2016; Huang, Yang, Chiang, & Su, 2016). These technologies make it possible to join different fields of knowledge, producing a confluence of these different types of issues, and generating a complementarity of contents, methods and objectives.

Techniques such as Augmented Reality (AR) have been under development in the last 25 years, in direct proportion to the increased capacities and types of hardware, and particularly with today's growing importance of mobile devices and applications (smartphones and tablets). Thus, it is possible to find interesting new features for users and software developers, enabling the creation of content related to AR activities. This scenario has seen a practical incorporation into various fields of knowledge, among which are education and heritage, where there have been important implementations of thematic content, creating a new way to display and disseminate information present in the territory. In parallel, another technology that has been strengthened by advances in mobile devices, has been Mobile Pedestrian Navigation (MPN) (Elhoushi, Georgy, Noureldin, & Korenberg, 2016), which derives from the use of navigation assisted by digital systems and of map servers, which allows the implementation of different thematic contents with consequences on their educational implementation. Both technological elements have been incorporated in different educational activities ranging from contents about environment (Kamarainen et al., 2013), to heritage and history (Chang, Hou, Pan, Sung, & Chang, 2015). However most of existing research is presented solely from a qualitative point of view through observations, interviews or observation groups, or from quantitative methodologies in experimental fields (Sommerauer & Müller, 2014). The purpose of these types of research is to determine the effect of the tools in learning achievement. To contribute to research in this area, we have conducted this study to measure the effects of AR and MPN learning from an m-learning context, comparing the results of these tools in e-learning contexts and in formal education settings (classroom).

Thus, the general objective of the study is the design and evaluation of a mobile application linked to the MPN and the AR, and framed within a process of educational training with the inclusion of technology (e-learning as a control group and m-learning as an experimental group). This is done within a framework of territorial information on the relevant historical and cultural heritage of the city of Santiago de Chile. From this context, we make use of a quasi-experimental methodology that establishes the hypothesis that students achieve higher levels of content acquisition (learning) on heritage and its elements using tablets and in a context of fieldwork (m-learning), when compared to activities developed by means of traditional teaching e-learning conducted in the classroom through a desktop computer. The theoretical foundation for this hypothesis is based on the cognitive theory of multimedia learning (CTML) and of the development of spatial intelligence. We approach e-learning and m-learning through the implementation of AR, digital mapping and MPN as applied to contents concerning historical, architectural and geographical aspects.

This document is structured as follows: the theoretical context of AR and digital mapping is shown first, both in educational processes and in situations of m-learning and e-learning context. Later, the quasi-experimental design used is described, emphasizing the treatments applied, as well as the test applied to measure the contents and processes. The rest of the paper deals with the statistical analysis of the results obtained, and includes evidence of the degree of satisfaction of educational activities carried out by the students and teachers who participated in the experience, incorporating interviews which produced information on particular elements of the educational process related to the use of technology. The discussion section compares the results with similar research efforts by other authors, and finally concludes with a summary and a reflection on the scope of the investigation.

2. Theoretical background

M-learning as a method of learning is directly related to e-learning, although it belongs indeed to an independent typology, where teaching and learning processes have an electronic and technological context, provided with the dynamism or movement and portability offered by some devices (smartphones and tablets) with high processing performance and storage capacity for digital information (Sánchez Prieto, Olmos Migueláñez, & García Peñalvo, 2013; 2016). Thus, m-learning would be a natural evolution of e-learning, allowing to students and users to have a learning process through mobile technology. Within an everyday context, navigation and the use of spatial mental maps are part of the understanding of the world in a person's mind. Distances, locations and relationships in and within the territory become a part of a cognitive process and find a place in human thought itself. The resolution of these spatial problems by means of computers (digital cartography and MPN) requires the generation of a navigation structure, that is, a further characterization of a territorial model that allows us to understand the spatial reality of subjects (Gardner, 2006). These elements have already been employed in mapping and navigation systems, which since ancient times have tried to represent and communicate territorial scenarios. Nowadays,