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Using Augmented Reality and m-learning to optimize students performance in Higher Education

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Abstract

This paper presents an analysis of the educational experiences related to the use of mobile devices in the classroom. The article includes a proposal in which Augmented Reality technologies are applied to support the explanation of concepts by means of the addition of information to the object being recorded by a mobile device. This technique relies on analysis of the image features and their combination using a software application that overlaps stored data with real images. This methodology is set to improve the educational learning output of students through the application of these technological resources.

Keywords: Augmented reality, autonomous learning, m-learning, ICTs for education

1. Introduction

This paper proposes the application of augmented reality (AR) to a specific educational purpose. The scientific community has to guide students and citizens as to how best to manage and transform information into knowledge in an autonomous and independent way (Liaw, Hatala & Huang, 2010). Working at several institutions of higher education (namely the University of Oviedo, the Open University of Lisbon and the National Autonomous University of Mexico), we have tried to provide a technological answer to the need to achieve a social profit from the widespread use of mobile devices. This research is set to contribute to the application of new technologies in the educational sphere by using mobile devices and augmented reality to explain concepts in the classroom through the integration of graphic and textual information. The main idea is for the combination of these technologies to provide data that can be overlapped with images detected by the mobile device in real time; the additional information used to define and clarify concepts is obtained through access to Internet databases and the support of specific open source software.

This research relies on the idea that using new technologies can encourage users to explore certain areas of knowledge. In addition, the project is intended to motivate students, to provide a response to their main concerns and to support the inclusion of the most underprivileged in accessing knowledge and information. Outstanding

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technological progress has blurred the boundaries and limitations of the stages and fields in which knowledge is acquired, as we have shifted towards the 'lifelong learning paradigm'. The spatial educative reference has been transferred to an invisible virtual campus commanded by users themselves (Jones & Healing, 2010, p. 379). In this sense, these issues also link this research to non-regulated learning.

2. Mobile devices in new educational settings

The European Educational Framework has led to a renewal in the methodology of approaches to training; new models should focus on the training of student-citizens who are able to interact autonomously in the social dynamic that surrounds them (Meawad & Stubbs, 2008). Therefore, in teaching activities, distant educational models have gained momentum thanks to information and communication technologies and their current most versatile manifestation: mobile devices.

Students must have continuous access to information sources and each will individually interact with the data with a certain degree of flexibility (Gil & Pettersson, 2010) and from any place (Holzinger, Nischelwitzer & Meisenberger, 2005; Kurti, Spikol & Milrad, 2008). In this sense, mobile devices are useful single-user tools for managing information (Marin & Mohan, 2009) that can be effectively applied to educational settings. Thus, the role of teachers is essential in the management process of adapting messages and information to new platforms. Richardson (2006) states that students build networks beyond the physical limit of classroom walls, integrating communities around their interests, hobbies and concerns. This explains why closed environments and traditional methodologies have proven to be limited and inefficient within the current framework.

Any physical setting can be connected to a virtual space by means of online devices. Hence, new interactions occur between students/users in accessible and friendly environments (Järvelä et al. 2007, p. 77). Many authors underline how mobile devices are integrated via interactive dynamics, allowing communication as well as data exchange and face-to-face interaction (Chan et al., 2006; Gil, 2010).

A society based on the constant access to information implies that users are able to master appropriate management modes and command efficient communication strategies. The design of m-learning courses depends on effective educational theories and strategies. In addition, the nature of the content and type of course must relate to the cognitive abilities being developed (Ramos, Herrera & Ramirez, 2010, p. 206). Research suggests people rapidly adapt to these new resources without difficulty: the use of Pocket PC portable devices in learning activities involving students aged 7 and 8 years old has been analysed. Results show a smooth and easy interaction between the students and the software used (Nussbaum et al., 2007, p. 196).

Besides mobility and versatility, there are additional features and benefits to be observed in the new approaches involving learning with mobile devices (Kukulska-Hulme, 2009; Hwang et al. 2010):

- Permanence: documents may remain multi-copied in different formats.
- Accessibility: data are accessible from different sources.
- Immediacy: information can be immediately accessed at any time.
- Interactivity: one-to-one interaction is established among users.
- Situated activities: learning is integrated into daily life; problems and the knowledge required to overcome them are presented in a natural and authentic way.
- Adaptability: students are provided with information that meets their personal needs in the appropriate way and at the correct time and place.

Holzingeret, Nischelwitzer and Meisenberger (2005) discuss the idea of mobile learning as a trend in education which is able to solve the space-time problem. They describe the difficulty of working with portable computers in multiple places and at multiple moments in time: this can be solved by means of using more versatile devices such as mobile phones. Dawabi, Wessner and Neuhold (2004, p. 57) define the way in which these mobile technologies can be used to access the Internet and in the autonomous management of data and learning objects. However, these authors also describe certain limitations such as the deficiency in the capacity of the network to keep users connected at any time and from any place. Within the framework of this new ecology of information, Cisco (2011) estimates that mobile devices manage about 40% of data whilst on the move, around 35% from home and the remaining 25% from work or places of study.

2.1. Teaching experiences related to mobile devices

Several authors have explored the pedagogic potential of mobile devices, focusing on their own interest in educational settings and assessing the possible uses of this technology. Williams et al. (2005) analyse the benefits and efficiency of transmitting information beyond the educational field and building knowledge using mobile phones. Similarly, the way in which children can work in a number of different subjects at school has been analysed by different scholars (Nilsson, Sollervall & Milrad, 2009; Gil, Andersson & Milrad, 2010; Spikol & Elisasson, 2010). It is also worth mentioning the work that has taken place looking at the recreational side of these resources (Facer et al., 2004; Spikol & Milrad, 2008). Similarly, some research has been devoted to the study of the application of mobile devices in the context of museums. The UK Department for Culture, Media and Sport of the developed and evaluated the use of mobile technology by students visiting museums and art galleries (Sharples et al., 2007); this study relied on data provided in three different museums by 3,000 students, and addressed the problem of the preparation for visits and their connection to classroom activities and topics.

Experiences involving mobile devices have provided significant contributions: for instance, Project AMULETS (Advanced Mobile and Ubiquitous Learning Environments for Teachers and Students) explored how best to design, implement and evaluate innovative educational settings supported by mobile phones and ubiquitous computing. Project MOSAIC Learning developed a model to evaluate mobile and ubiquitous technologies as a learning support alternative that can be integrated into the lives of students and teachers (Ramirez, Munoz & Delgado 2008). The work of Garcia and Monferrer (2009) analyses the different ways in which teenagers use their mobile phones; this contribution formed the basis of a study into the use of mobile resources by young people and provided an approach to the instrumental and symbolic dimensions of this means of communication. In addition, this research also contributes to the analysis of the different functions (recreational, expressive, referential and communicative) of mobile technologies.

2.2. Teaching experiences based on mobile devices.

Several studies have been conducted into the use of mobile phones and micro-computers (PDAs) which reproduce texts. Some of the most relevant work has been completed by Hartnell and Veter (2005), who explore the use of blogs on mobile phones, and by Nussbaum et al. (2007), who investigate the use of PDAs to promote group learning in schools. With this aim, Nussbaum et al. designed an interface that presents multiple-choice questions to be answered by students in a collaborative way; in the cases where there is no agreement or the answer is incorrect, the group must discuss and negotiate the possible answers as a whole. This process is remotely monitored by teachers, who can assess the progress of every group and any problems they encounter.

Xiaoyan, Ruimin and Minjuan (2007) present a mobile learning system where the whole classroom is based online, with students sending text messages to the teacher and communicating amongst themselves using their mobile phones. These text messages can include questions, suggestions and enquiries, or relate to any other need the students may have. The teacher answers the messages by means of a screen (writing on it or providing an oral response). Through the use of fast access pre-created messages, students can inform the teacher that the rhythm is too fast, the handwriting difficult to read or that he or she is speaking too quietly. Likewise, the teacher can monitor the work of every student in real time.

Finally, Lynch, White and Johnson (2010) analyse how students favour text messages as well as the tendencies of what students prefer and which content encourages them to use their mobile phones.

2.3. Teaching experiences based on mobile phone videos

The development of compression techniques has provided the ability to limit the quality of video signals in order to send videos using mobile phones at a suitable speed and an affordable cost. Kantarci (2010) investigated the adaptation of content to the transmission speed of video signals and the reproduction quality of audiovisual documents (streaming). The amount of bandwidth required was analysed, as well as the content and the demands of receptors. This study can be considered to be complementary to the work exploring the suitable levels and formulas of video signal compression previously carried out by Fill and Ottewill (2006) and Liu, Wang and Liu (2009).

The Project Digital Narrative presents an approach to the collaborative creation of videos captured with mobile phones. In order to do this, an argument was defined amongst participants and a conceptual map created to develop the whole production (Sanchez & Tangney, 2006, p. 257). Some experiences highlight the current ease of handling video files due to the development of specific software (Everhart, 2009); indeed, students are becoming get used to exporting files documents between YouTube and their portable devices.

The Danish Project Flex-Learn studied new ways to provide support for lorry drivers by means of video lessons distributed using mobile phones (Gjedde, 2008). Similarly, the work by De Waard et al. (2007) is of particular interest, as these authors analyse the video distribution model for portable electronic devices (vodcasts), which allow subscribers to interact with each other, supporting pair work and reducing cultural and regional differences as well as possible gaps in learning experiences. Continuing along this line of research, Mann, Wong and Park (2009) analyse how students may have difficulties in comprehending complex concepts and how a mixed learning approach supported by vodcasts can be used to enrich the learning experience. In blended learning, a combination of face-to-face teaching, vodcasts, practical experiments and reports contributes to enriching and reinforcing the different learning styles of students. Most students unable to fully understand the content can obtain a positive outcome after watching the vodcast. In addition, students appreciate having the ability to control how to use the materials and being able to watch them as many times as they want. Other authors, such as Srinivasan, McLoughlin and Lin (2009) and Laaser, Jaskilioff and Rodriguez (2010), have studied the characteristics of audio and video transmissions in the educative field and support the assertion that they cannot be considered in isolation. Most proposals relating to the interaction between mobile and video devices in an educational setting are linked to the reproduction of brief explanatory videos.

3. Augmented Reality Technology: Typology

Augmented reality allows the linking of images with their corresponding metadata in real time. This connection is managed by an advanced mobile device, which enables integration with software that adds virtual components (i.e. messages, information) to real images and in real time. This system requires a powerful CPU and enough RAM memory to smoothly process the images taken by the cameras.

The device can also include a GPS system to detect the user's location. In this regard, the MOTEL Project (Mobile Technology Enhanced Learning) developed a specific infrastructure to support students and researchers in a mobile environment with geo-references by means of messages relating the position of and the information generated by the users.

Relying on the images taken by the camera, the real world can be simulated using a system of coordinates, orientation sensors, magnetometers, inclinometers, inertial sensors and other recent technologies, albeit with certain limitations that still need to be resolved (Bimber & Raskar, 2005; Basogain et al., 2007; Cawood & Fiala, 2008).

There are several open source software applications, such as ARToolKites (a GNU GPL library) that allows for the overlapping of information with images in real time. The following typology can be established:

Type 1- Geolocation: image including details of its geographic location (GPS) and other relevant data such as information on public establishments, guidelines and suggestions of traffic routes.

Type 2- Pattern/Tag/Marker/Quick-Response Code/Semacode: image with data regarding a specific original pattern: for instance, information on the handling of an engine, or an animation on any given pattern can be added (e.g. we can add information on the assembly process to the scheme of any type of machine).

Type 3- Image and software: this option allows differentiation between the key features captured by an application that turns them into measurements. Some applications such as *Augmesure* enable one to make simple measurements of distances between recorded objects.

Type 4- Recognition and browser: an image can be compared to related pictures on the Internet in order to add relevant information. For example, using face recognition software, information about the person appearing in the image can be added.

4. Augmented Reality in Educational Settings: a Proposal

The potential of video resources in the context of education has already been explored in examples of specific experiences (Vilchez, Sierra & Perales, 2004). However, some work (Gorra et al., 2010) outlines the sluggishness of teachers to adapt to the new setting and find possible uses and applications for the new technologies used by students. Regarding the use of mobile phones with augmented reality, we still need to explore the possible relevance to educational contexts (Hainich, 2009). Researchers from the University of Oviedo and the LEAD Laboratory of the Open University of Lisbon are currently working on this proposal with a global projection. The initial hypothesis relies on the fact that teachers can improve distant learning methodologies by taking advantage of the new possibilities which have emerged with the advent of mobile devices. The main objective is to improve concept explanations by adding information to the object recorded by the mobile device.

Resulting from the analysis of the most up to date technology and its most suitable adaptation to advanced mobile devices, we have designed a protocol for mobile phones which relies on a specific selection of the iconic features of the image taken (Fombona, 2008). These features relate to the corresponding metadata (Svensson, Pettersson & Persson, 2009; Svensson, Kurti & Milrad, 2010) and are analysed by software specific to augmented reality. The application proposal addresses the teaching staff eligible to use this resource; however, the project is not restricted to a specific educational stage.

The example proposed is defined on the basis of the existing free software (such as the application Look for Android). With this software, drawing applications for 2D and 3D elements can be developed in order to be overlapped with the images taken on a mobile phone. Users can easily include common objects such as text and basic forms. In addition, it provides tools to define colours and textures and features geometric functionalities in order to enable common tasks of graphic development: points, vectors, matrixes, plans and rays, as well as the related operations. This is open source software (GPL v3 License) that can be upgraded and extended. It also integrates the following features to create applications simply and quickly:

a. The drawing of 2D and 3D graphs
b. Allowing for the integration of graphs with the camera
c. The promotion of interaction with virtual objects
d. The construction of entities to be represented with augmented reality
e. In the normal dynamic of the classroom, the teacher draws the basic features of his or her proposal on the blackboard (e.g. the basic characteristics of a building, the shape of a country or any other iconic element). These can be captured by the mobile device software and will interact with the additional educational software used in this proposal.

The following example focuses on the field of mathematics: the idea is to record a real cylinder with the mobile phone and associate overlapped information on how to calculate its total surface area and volume. This information appears over the image on the screen of the mobile phone.


Figure 1. A mobile device is used to take pictures of different objects

The following information can be associated with the image:

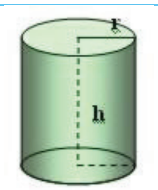	Area calculation $A_{total}= 2□r\ (h + r)$	Volume calculation $V= □\ r^2 \cdot h$

Figure 2. Mathematical calculations of 2 variables

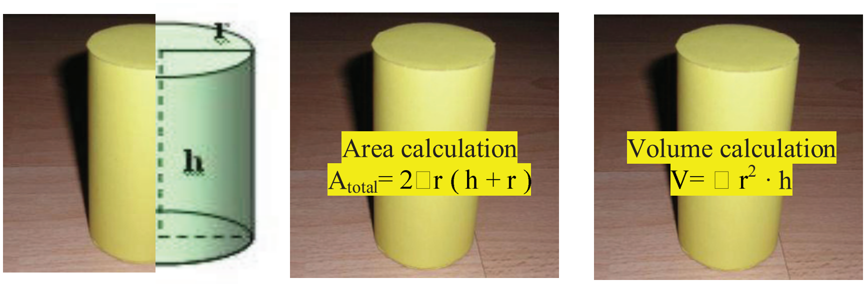

Figure 3. Integration of the calculations and the actual image

Beyond geometry, different applications for this methodology can be found in other areas. In all the cases, the three-dimensional interactions with the objects allow for a better comprehension of reality. This resource could be introduced in books, transforming them into interactive materials able to play explanatory videos relating to different content. With this type of application, we can stimulate the user's motivation to explore content. In addition, it promotes a higher capacity for spatial perception. Another potential area in which to apply the methodology is vocational training: for example, content could be presented and explained in a safer way for students and teachers.

Beyond the manifold possibilities commented on thus far, this proposal enables the creation of suitable learning environments adapted to the different learning styles of students. As a concluding remark, this proposal envisions a working environment where these techniques can be used as an alternative to the traditional iconic resources (blackboard, computer, projectors, etc.), as they are enhanced by additional information.

5. Conclusions

We live in a fast-paced society, with constant changes and modifications affecting technology and information management systems. Teachers are bound to take advantage of the benefits of ICT and rely on efficient methodologies to try to meet the demands of the global era. The use of mobile devices can be regarded as a useful tool as they are an attractive and widespread resource that guarantees access to information from any place and at any time. As for the educational application of mobile phones, the content of activities involving these devices necessarily relies on a strong audiovisual component, since an efficient and appealing narrative can have a positive influence on the learning process.

Combining mobile phones with augmented reality provides some methodological breakthroughs, as this technique can relate images taken with a device and link them with stored metadata. The possible uses explored in this paper clearly show the application of mobile devices and augmented reality in the context of education. Beyond the description of particular instances where augmented reality can be used in the classroom, the underlying goal of this research is to highlight the need for the exploration of the application of new technologies to teaching methodologies and the study of the possible impact these innovative initiatives may have on the learning output of students.

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