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CATEGORIZATION OF AUGMENTED REALITY AND GEOLOCATION APPLICATIONS FOR MOBILE LEARNING

CATEGORIZACIÓN DE LAS APLICACIONES DE REALIDAD AUMENTADA Y GEOLOCALIZACIÓN PARA EL APRENDIZAJE MÓVIL

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Abstract

This educational research focuses on describing the potential of the advanced digital mobile devices, especially the Augmented Reality, AR, and Geolocation techniques. A number of 231 students experienced and recorded the characteristics of 231 apps to group them into several categories. We, then, turn to describe the potential of AR to create engaging e-learning experiences in field activities. Similarly, Geolocation and Global Positioning System, GPS technology, allow the interaction between the users and their geographical situation. It also enables them to download information about the place, or other activity associated with a spot. These ICT resources motivate students and generate a challenge for developing classical tasks in a more dynamic and collaborative way, within the traditional educational framework. For the first time, static places and specific moments to access information disappear. M-learning modifies teaching methods since the spatial reference of the classroom changes through a physical and virtual context dominated by the user, with an absent teacher.

Keywords: computer software, educational research, electronic learning, ICT, mobile learning.

Resumen

Esta investigación describe el potencial educativo de los dispositivos móviles digitales avanzados, especialmente, aquellos con las técnicas de Realidad Aumentada, RA y Geolocalización. Participaron 231 estudiantes, quienes experimentaron y registraron las características de 231 apps, agrupadas en diversas categorías. Esto posibilitó la descripción del potencial de RA para crear atractivas experiencias de aprendizaje en-línea durante las salidas de campo. Se analizaron las tecnologías GPS y Geolocalización, las que permiten la interacción entre los usuarios y su situación geográfica, además de permitir descargar información acerca de un lugar específico. Estos recursos tecnológicos motivan a los estudiantes y posibilitan el desarrollo de tareas clásicas de forma más dinámica y colaborativa: desaparecen los lugares concretos y los momentos específicos para acceder a la información. El m-learning modifica las metodologías didácticas, ya que la referencia espacial del aula cambia por un contexto físico y virtual dominado por el usuario, sin presencia del docente.

Palabras clave: aprendizaje móvil, aprendizaje en línea, investigación pedagógica, programa informático, TIC.

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1. Introduction

A new way to build knowledge is emerging and daily routines increasingly require access to information systems in a mobile and instantaneous manner (Geiger, Schickler, Pryss, Schobel & Reichert, 2014). This document is a brief introduction to a larger Spanish study. On the one hand, we know it is necessary to improve the educational learning output of students using new devices, as new technologies seem to encourage users to explore several fields of knowledge. On the other hand, this study also supports the inclusion of everyone as an IT user, in the information and knowledge society. This research relies on the assumption that the impact of mobile devices modified the common learning panorama, so the virtual campus and other online platforms allow users to command and control certain areas of their learning process. In addition, in current settings, training and knowledge are acquired at different moments, promoting a lifelong learning experience.

Nowadays, technology and education have an international dimension and teaching and learning methodologies must necessarily refer to the best practices carried out in every part of the world. In this respect, technology has become a model for the consistent implementation of new devices and new digital literacy policies accordingly. The main goals of the industry and the goals of our educational activity are heading in opposite directions. Recently, the mass media took over the power of television. Now, the Internet offers multiple channels and broadcasting messages based on images. Furthermore, school libraries are full of underused videos, partly because of the inherent complexity of the communication strategies audiovisual information and due to the lack of experience of educators (Fombona, 1997; Vázquez-Cano, Fombona & Fernández, 2013). Undoubtedly, the media uses an audiovisual language strategy which is unknown by teachers. In fact, mobile devices are using the former narrative of media: individualized messages, aimed at people with particular profiles, and using forms where the emotional aspect prevails (Fombona & Mampaso, 2010).

Educational policies should promote and grant a full approach to technology, as well as to resolve its scarcity and deficiencies to provide a wide Internet coverage nation-wide. Concerning this, the relatively limited amount of schools with full Internet access in any country, contrasts with the high percentage of penetration of state-of-the-art mobile devices among their citizens (Blignaut, Els & Howie, 2010, 565). It is, therefore, of utmost importance that we profit from the affordances of those mobile devices by implementing their use into the classrooms.

There are several key issues in the interaction generated by mobile devices. First, there is a highly positive motivational component about working with these tools, especially in young people. Second, each case generates a personalized and different relationship. In addition, working with these tools can be done anywhere at any time. Consequently, the task is done in moments of formal and informal activity. The Psychology of Simultaneity explained this new man-machine link.

Teachers can take advantage of the emotional attachment of our students to their Smartphone. However, it is not easy to implement new learning methodologies, and in addition, we are used to the constant arrival of new software. Nowadays, software stores for mobile devices currently offer millions of applications, and among them we must select the most appropriate and remain stable over time. Therefore, we analyzed general techniques based on location, in order to detect contextual objects, and implementation of activities based on mobile Augmented Reality, AR, since they present an exact set of appropriate uses for both training within schools, and field trips (Fombona, Pascual & Amador, 2012). Augmented Reality combines a display of digital information stored with a view of the real world, as captured by a mobile device; so it is possible to create engaging learning experiences in field activities and interaction with the environment.

This technology is a new way of exploring certain knowledge areas. This format makes the user have more information of a given object through the potential and charm of today's mobile device technology alongside with the incorporated virtual reality. This motivating aspect could have an important application in the education field where they must respond to students' concerns, as well as support the integration of lifelong learning in the knowledge society. This technological development makes the stages and fields in which we gain knowledge neither specific nor vague and would extend situational awareness. With this technology, we can move from a static perspective to a more dynamic environment controlled by its user.

2. Methodology

Our goal is to analyze, from a methodological perspective, the use of these techniques and make an updated coherent sorting proposal. The focus is to classify the several applications (Apps) of Augmented Reality and Geolocation technologies. We also try to exemplify each case and evaluate the educational potential of AR and Geolocation software through a random sample of educational Apps on Google Play (https://play.google.com/store/apps) and Apple Store (https://itunes.apple.com). The Apps were thoroughly tested. Moreover, the gathered data were analyzed, labeled and broken into categories with WinEdt 5.6 and CAQDAS Atlas-Ti (7.0). We have differentiated two types of applications, the categorization "Geolocation app" and "AR app" cuts across, and we have also made a difference between Android applications (162) and IOS applications (103). Out of them, we tested a total number of 138 Android apps and 93 IOS apps. In the experimental part, 231 secondary school Spanish students experienced and recorded the characteristics of 231 apps (one application for each student) to group them into several main categories. As part of the supervision and validation process, researchers on mobile technology and specialized personnel have overseen the test.

This descriptive and qualitative part of the study was organized into two stages. Stage one was developed according to ”data reduction” principles. It consisted in developing rational procedures, such as categorization and data codification, and identifying and differentiating units of meaning. The procedures were the following: ”data categorization”, which involves simplifying and selecting information to make it more manageable. ”Unit identification and classifying” was established to conceptually classify the following units: Type 1- Apps for Geolocation, type 2- Augmented Reality apps launching data, type 3- Apps image and software combination, and type 4- Applications to recognize figures and Internet links. In stage two, we developed ”synthesis and grouping processes” by the creation of a net in Atlas-Ti. These processes complemented the categorization and data codification procedures and we obtained the most representative categories for mobile learning.

2.1 Descriptive analysis: a rise of mobile devices

More and more citizens own advanced mobile devices. Traffic of phone data has grown exponentially and globally during the last decade. The French company SFR has seen how its annual flow triples since 2008; Vodafone increased its traffic by 88% in the second quarter of 2010 regarding the same period of the previous year (video resources represent 49.8% of this flow). According to statistics, YouTube videos in mobile phones tripled in 2010, reaching 200 million videos per day (Cisco, 2013). The traffic generated by every Smartphone went from 35 megabytes per month in 2009 to 79 in 2010. Smartphones represent 13% of the total amount of mobile devices connected to the Internet, but they stand for 78% of the traffic generated by these appliances (Cisco, 2011).

The data traffic generated by portable devices grew by 160% from 2009 to 2010, reaching about 237 petabytes per month; 48 million people in the world have a mobile phone although they do not have electricity at home. By the end of 2011, in the sub-Saharan Africa and South-East Asia, there were more cellular phone subscribers than people connected to the electric supply. Ostensibly, a similar situation occurred in the Middle East by 2013 and in India and the nearby countries in South of Asia by 2015 too. At this time, surprisingly, the number of people connected to the Internet without electric supply at home accounted for 137 million (Cisco, 2013). Currently, mobile Internet traffic is growing 133 % per year. Nowadays, smartphones and tablets increase their computing power and decrease its price. There are fast emerging communications networks, such as 4G and Wi-Fi, to access more applications, particularly data-intensive video (Cisco, 2015).

According to the estimations of Wireless Intelligence (Global database of Mobile Market Information), between 2010 and 2014, there were 7,100 million portable accesses to the Internet, almost a connection per person on the planet. The number of mobile phones in Latin America reached 90% thanks to the strength of certain markets (e.g. in Argentina and Chile mobile phones exceed their inhabitants). It is interesting to highlight the case of Mexico, where there are 86 million cellular phone connections and phones reach 76% penetration in the population. The number of world mobile phone connections can be summarized as follows (Wireless Intelligence, 2010):

- Asia Pacific: 2,353 million
- Latin America: 528.8 million
- Western Europe: 514.9 million
- East Europe: 491.6 million
- Africa: 485.8 million
- USA and Canada: 313 million
- Middle East: 279. 5 million.

2.2 Descriptive analysis: rise of m-learning

To this date, related educational experiences have not grown at the same rate. Several authors have explored the pedagogic potential of mobile devices, focusing on their interest in educational settings and assessing the possible uses of this technology. Williams, Jones, Fleuriot & Wood (2005) analyze the benefits and efficiency of transmitting information beyond the teaching area and building knowledge using mobile phones. Along the same lines, several scholars figured out the way in which children can work in different subjects at school (Gil, Andersson & Milrad, 2010; Nilsson, Sollervall & Milrad, 2009; Spikol & Elisasson, 2010). At the University level, different studies have been developed mainly on the integration of mobile devices to support formal and non-formal activities (Sevillano

& Vázquez-Cano, 2015; Vázquez-Cano, 2014). It is also noteworthy to mention the works on the recreational side of these resources (Facer, Joiner, Stanton, Reid, Hull & Kirk, 2004; Spikol & Milrad, 2008). Later, and in a widespread way, the England's Department of Culture, Media and Sports developed and tested the use of mobile technology by students when visiting museums and art galleries. This study relied on data provided by 3,050 students in 3 different showrooms, and it allowed addressing the problem of the preparation of visits and how to connect with the activities and topics of the classroom (Sharples, Lonsdale, Meek, Rudman & Vavoula, 2007). Accordingly, many types of research have been devoted to the study of the application of mobile devices in this type of public rooms (FitzGerald, et al., 2013).

The experiences with mobile devices have provided significant contributions: the Project AMULETS (Advanced Mobile and Ubiquitous Learning Environments for Teachers and Students) explores how to design, implement, and evaluate innovative educational settings supported by mobile phones and ubiquitous computing. Similarly, the MOSAIC Learning Project (http://mosaic.gast.it.uc3m.es) developed a model to assess mobile and ubiquitous technologies as an alternative learning support, and it could be integrated into the life of students and teachers (Ramirez, Muñoz & Delgado, 2008). Garcia and Monferrer (2009) analyze the different ways in which teenagers utilize their mobile phones; this contribution set the basis to study the use of these resources by young people and provides an approach to the symbolic and instrumental dimension of this means of communication. In addition, this work also contributes to the analysis of the different functions (recreational, expressive, referential, and communicative) of mobile technologies.

For a decade, there has been an increasing interest in applying Augmented Reality to create unique educational settings. It is interesting to make a systematic review of the literature on this technique from Bacca, Baldiris, Fabregat, Graf & Kinshuk (2014) who published 32 articles between 2003 and 2013, in educational areas considering uses, limitations, advantages, effectiveness, challenges, and features of Augmented Reality technology in this formative context.

Research on the use of mobile devices with Augmented Reality technique is insufficient. Experts have not explored yet the impact of these methodologies in the training process (Hainich, 2009). On the contrary, AR is a medium increasingly used by publishers, video games creators, and marketing strategists. The aforementioned may indicate the potential this technology has to improve student learning, especially for the young user in the levels of primary and secondary school (Radu, 2014). However, the teacher should not be merely a technology seller. The school should take and adapt some of these strategies, such as personalized communication, self-directed learning, and possibilities of inclusive environments arising from the use of RA. For example, Augmented Reality can use an interactive game which mimics the movement of the body to help children with disabilities (Chien-Yu & Yu-Ming, 2014).

A significant aspect is the use of RA and Geolocation in creating favourable scenarios for researching. Chiang, Yang and Hwang (2014) investigated the performance of learning activities in which the student is involved in self-discovery tasks. Their experimental results showed how this approach improves learning achievements of students. Perhaps, after using Augmented Reality and Geolocation techniques, their most important finding is that students showed significantly higher motivations in attention, trust, and the dimensions of relevance than those who worked with the approach of mobile learning based on the traditional way.

3. Results

3.1 Exploring a valid classification of mobile digital devices

Quinn (2000) defined educational possibilities of m-learning: its interactivity, connectivity, and electronic data processing in a small device with the option of being online. This definition applies to devices such as mobile phones, smartphones, Blackberries, iPhones, Tablets, and micro-computers. Similarly, it also relates to the intervention of different protocols, interfaces and communication accessories like Bluetooth, IRDA, RFID, GPS, or 3G, to mention a few examples. There are portable video-games offering the choice of playing videos and music. The differences in the interface increase the range of possibilities: touch-screen systems, keyboards with a joystick, the way to access the Internet, among others. In many of these cases, we can detect the mixed offer of services analyzed: Internet access, document management, and multimedia playing. Therefore, a definition of the research field is required due to the high number of functionalities and mobile devices. In 2005, DuPont Global Mobility Innovation Team and other institutions proposed the following standards for the definition of mobile devices:

- Limited Data Mobile Device: they have a small screen, and they are limited to SMS and WAP access. In this sense, we observe that mobile phones are used to talk and send text messages.
- Basic Data Mobile Device: they have a medium-size screen, a menu or navigation system based on icons using a “wheel” or a pointer, and they offer e-mail access, ad-

dress book, text messages and a simple web navigator. Smartphones can be included in this category.

- Enhanced Data Mobile Device: tablets, minicomputers, devices with medium or large screens, touch-screen and "Basic Data Mobile Device" provided with a particular Operative System such as Microsoft Office Mobile and mobile version applications.

Cisco (2015) makes a more accurate classification of portable digital tools:

- Not smartphones: handheld phones with a closed operating system for basic communicative functions.
- Smartphones: these mobile phones are offering advanced capabilities such as the ability to run applications, run complete operating system software, often with functionality similar to a PC.
- Laptops: laptop computers, netbooks, and ultra-mobile PCs connected to the mobile network through mobile broadband data cards, embedded modems, or mobile hotspots.
- Tablets: mobile-connected tablets (usually with an average screen size of 7 inches) and what are commonly referred to as mobile Internet devices (typically with an average screen size of 4 to 6inches).
- Other portables: e-readers, handheld gaming consoles, and car entertainment systems.
- M2M modules: machine to machine technologies that allow systems to communicate with other devices of the same capability, such as utility metering, security and surveillance, fleet management, GPS and navigation, asset tracking, and record healthcare devices.
- Wearable equipment: smart-watches, smart glasses, heads up displays (HUD), health and fitness trackers, health monitors, wearable scanners and navigation equipment to smart clothing and more. Devices that people wear, which are capable of connecting to and communicating with the network, either directly through embedded cellular connectivity, or another tool (primarily a smartphone) over Wi-Fi, Bluetooth, and so forth.

Currently, most of these devices meet the requirements to run AR and geolocation technologies; namely, graphical interface, camera, Global Positioning System (GPS), compass, magnetometer and accelerometer sensor, with an increasingly and precise operation (Sokolović, Dikić, Marković, Stančić & Lukić, 2015).

3.2 Exploring a valid classification of the Augmented Reality Technology

The categorization process in Atlas-Ti is represented by a net which shows four types of applications:

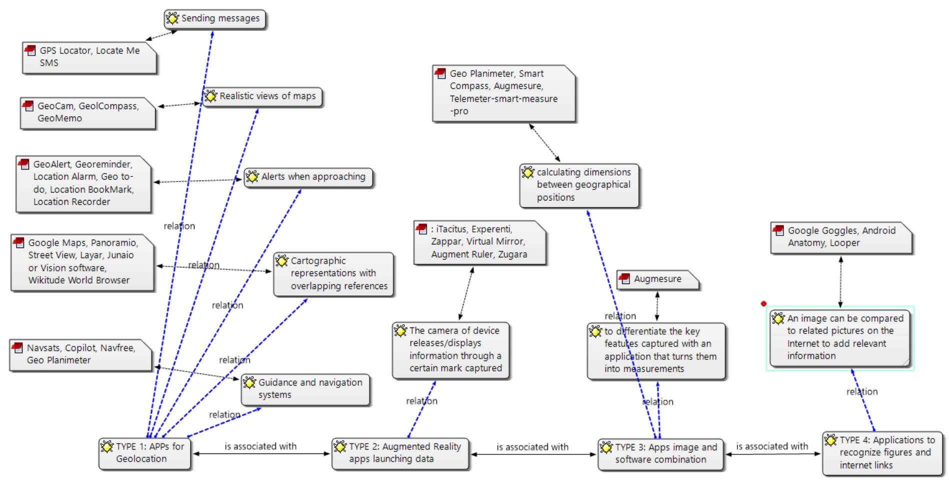

Figure 1. Process in Atlas-Ti software.

The four types of Apps related to the Augmented Reality technology and Geolocation are described below.

Type 1- Apps for Geolocation: Image including details on its geographic location and other relevant data (Fig.2), such as information on public establishments, guidelines, and suggestions on traffic routes. The user can be in any specific position within the terrestrial coordinates through a GPS system, and at the same time, information about close places is added. Over the picture there is also data relating to its geographical position and other data about it available on the internet, such as traffic directions, information about public establishments, to name a few. An example could be a captured image of a street where data of other close streets or characteristics of visible stores are integrated.

Figure 2. Image with GPS coordinates and stored information.

There are several examples, for instance:

- Different Apps that focus on user guidance and navigation systems (Navsats, Copilot, Navfree, Geo Planimeter, etc.);
- Cartographic representations with overlapping references (e.g. Google Maps, Panoramio, Street View, Layar, Junaio or Vision software, Wikitude World Browser, etc.);
- Information about the situation of other users (e.g. GeoProximity, etc.);
- Alerts when approaching a specific position (e.g. GeoAlert, Georeminder, Location Alarm, Geo to-do, Location BookMark, Location Recorder, etc.);

And Apps combining the above techniques, providing references with realistic views of maps (e.g. GeoCam, Geol Compass, Geo Memo, etc.), and sending messages (e.g. GPS Locator, Locate MeSMS, etc.).

Type 2- Data Launching Augmented Reality Apps: The camera of the device displays information through a captured mark, Pattern, Tag, Marker, Quick Response Code QR, or Semacode. Image with data regarding a peculiar and original pattern (Fig.3), for instance, we can add an animation on any given reference, or information on the repair process of a machine (e.g. on the assembling process to the scheme of an engine). There are many examples: iTacitus, Experenti, Zappar, Virtual Mirror, Augment Ruler, Zugara, and so forth. This operation shows a picture on top with other data relating to a precise and original standard; this allows to overlap information about a known a priori key-image, for example handling data of a motor, or an activity about a given procedure. So, the diagram of a captured machine, the procedure for its dismantling, and others can be easily added. Today, key-images can illustrate publishing business, so small AR animations or 3D AR figures are joining the books.

Figure 3. Pattern image launches a stored animation.

Type 3- Apps of image and software combination: This option allows to differentiate the key features of an image with an application that turns them into measurements (Fig. 4). Some applications like Augmesure enable to make simple measurements of distances between recorded objects. These Apps calculate dimensions between geographical positions and other mathematical calculation (e.g. GeoPlanimeter, Smart Compass, Augmesure, Telemeter-smart-measure-pro, Geo-engineering, etc.).

Type 4- Applications to recognize figures and internet links: An image can be compared to related pictures on the Internet to add relevant information (Fig. 5). Information on the person appearing in the photograph can be added using face recognition software. Currently, there are several examples of such applications: Google Goggles, Android Anatomy, Looper, etc. Then, for instance, face recognition software could give information about the captured person. Nowadays software that uses this potentiality is already distributed. Google Goggles can recognize the following filmed elements from its databases: logotypes, labels of any commercial products, works of art, title pages of books, tourist places of interest, and written text.

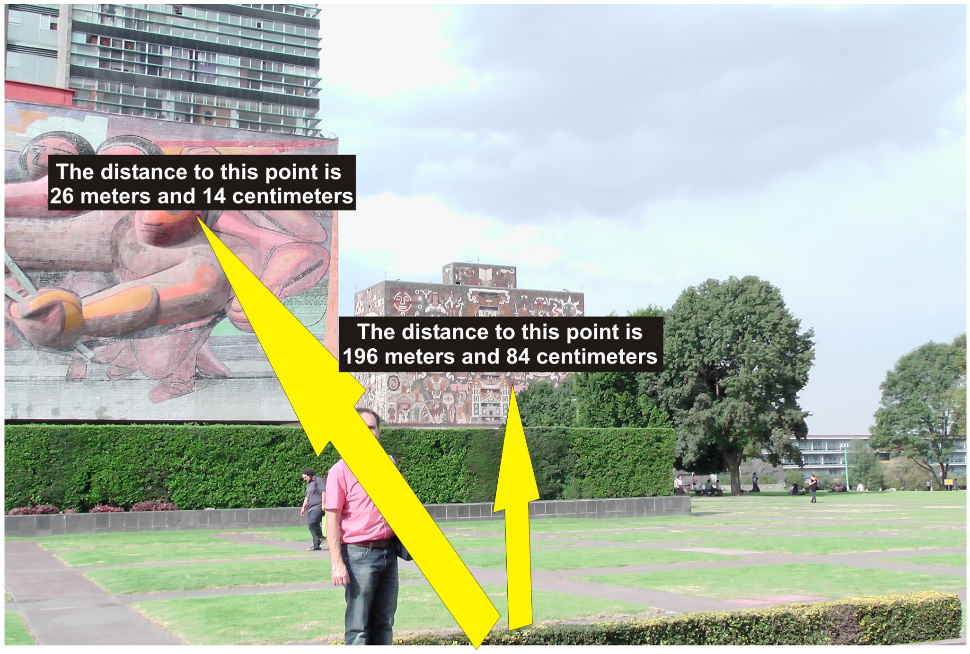

Figure 4. Image analyzed in interaction calculating the distances.

Figure 5. Image analyzed with WEB interaction.

These four types of applications could contribute to acquire three main digital competences with applicability in all school subjects, according to DIGCOM (2013):

1. Information: identify, locate, retrieve, store, organize and analyze digital information; judging its relevance and purpose. For these goals, the analyzed applications could help students to adjust searches according to specific needs, they can have strategic information skills for goal oriented activities and they can transform information into knowledge. Students can compare, contrast, and integrate information from different sources and they are able to understand how information could be enriched to generate knowledge.

2. Communication: communicate in digital environments, share resources through online tools, link with others and collaborate through digital tools, interact with and participate in communities and networks, cross-cultural awareness. For this competence, Augmented Reality and geolocation applications could help students to interact through a variety of digital devices and applications; to understand how digital communication is distributed, displayed and managed; to understand appropriate ways of communicating through digital means; to refer to different communication formats; to adapt communication modes and strategies to the particular audience. Furthermore, students are able to share with others the location and content of information found; to be willing and able to share knowledge, content and resources; to act as an intermediary; to be proactive in the spreading of news, content and resources. The use of these applications can contribute to use technologies and media for teamwork, collaborative processes, and co-construction and co-creation of resources, knowledge, and content.

3. Content creation: Create and edit new content (from word processing to images and video); integrate and re-elaborate previous knowledge and content; produce creative expressions, media outputs and programming; deal with and apply intellectual property rights and licenses. These applications enable the students' skills to modify, refine and mash-up existing resources and to create new ones, original and relevant content and knowledge.

4. Discussion and Conclusions

Activities related to personal use of Smartphones, Laptops, Tablets, Wearable devices and other portables, enjoy a growing popularity and connect the world through a new and powerful way of interacting and getting information (Mark, Molina & Gordon, 2013). Some new associated technologies are arising, surrounded by appealing characteristics, as the case of Augmented Reality technique. This technology instantly puts data on top of the physical reality we capture with the mobile device; the access to Internet or databases and express software allows the user to overlay any digital information into any shot. The combination of AR with Geolocation technology becomes even more attractive to students.

However, we need to classify the technological offer without seeking commercial gain. Citizens must be oriented by the scientific community on how to manage and transform information into wisdom (Liaw, Hatala & Huang, 2010). Moreover, from different higher institutions (Aberta, Portugal University; UNED, Spain; and Oviedo University, Spain), we are trying to clarify some typical uses of mobile devices, the most widely social technological phenomenon.

More and more citizens have advanced equipment, which could help to improve the knowledge of the user. We need to rethink and gather ideas about how to grapple with the media teaching-learning process and about the academic use these tools to understand its implications for the comprehensive educational system, in an increasingly more diverse and globalized environment. There are technological issues we have to manage, so there is some resistance to incorporate these strategies in the school world, especially with the problems smartphones are giving schools at Middle School level. Currently, many see them as disruptive devices rather than educational tools and few teachers attempt to use mobiles in an innovative way. Most schools still have policies forbidding mobile use within the classroom, but this is changing as mobile devices (cell phones and tablets) and portable computers are becoming do-it-all devices, indispensable for training.

The environmental crisis demands that we give answers to society with the purpose of progressing and updating methodological approaches in information management, which can contribute to knowledge construction. Efforts are directed towards the education of a student-citizen that is able to interact autonomously and efficiently in the society that surrounds him. Users must keep, continuously, the path to open information sources, and they will be the only ones who access the data in a flexible way and anywhere, even without the presence of the teacher. This is an independent means to solve problems, without needing to be in the classroom or a traditional library. Any time and space are adequate for access to information, and we are obliged to lean on ICT in their versatile version: mobile devices as useful single-user tools.

People build networks beyond the walls of classrooms, work, or home: they create communities around their passions and talents, and this can explain why closed environments and traditional methodologies appear more and more limited and inefficient. Each physical space can connect with another distant place through such networked devices; all this generates constant new interactions between users/students in friendly and accessible environments. We want to emphasize the possibilities of mobile devices to foster interactive dynamics, facilitating communication between peers, face-to-face interaction, and collaboration. Furthermore, these new devices modify the relationships between students and teachers, and how they can influence educational methodologies, implementing a playful dynamic, obtaining punctual responses to problems, facilitating ubiquitous teaching and learning processes, and creating moments of evaluation through communicational feedback. Teachers could use these tools because all students have these digital devices, and they could take advantage of these options to create new learning paths.

A society based on constant access to information demands to know how to manage all the data and control of efficient communication strategies. Then, the design of m-learning resources must be supported by educational theories and different strategies, combined in ways that make them effective. Therefore, it is very important for an adequate development of students' cognitive skills to take into account both topics and digital tools.

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