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The educational possibilities of Augmented Reality

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ABSTRACT

A large number of emergent technologies have been acquiring a strong impulse in recent years. One of these emergent technologies is Augmented Reality (RA), which will surely have a high level of penetration into all our educational centers, including universities, in the next 3 to 5 years, as a number of different reports have already highlighted.

The present paper shows various elements which, in our opinion, play an essential role when it comes to the incorporation of Augmented Reality into teaching, stressing the fact that this incorporation should not entail a technological problem but an educational and didactic issue. A mention is additionally made of several studies which have been performed with regard to the didactic exploitation of this emergent technology, as well as to the potential that it offers us. Our study forms part of an R&D&I initiative undertaken within the framework of the *Plan Estatal de Fomento de la Investigación Científica y Técnica de Excelencia 2013-2016* [2013-16 State (National) Plan for the Promotion of Excellence Scientific and Technical Research], with reference EDU2014-57446-P.

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1 AUGMENTED REALITY: DEFINITION, TYPES AND PROGRAMS

A variety of emergent technologies (semantic web, gamification, cloud computing, learning analytics, MOOC, Internet of things, personal learning environments…) have been gaining more and more strength since the start of this century thanks to various events, which range from the importance that the web 2.0 has gradually acquired along with the reduction in equipment costs to the strong penetration of mobile devices which have had an undeniable influence on the relocation of technologies. Amongst these emergent technologies stands out the so-called 'augmented reality' (AR), a technology that, as suggested by different reports (Durall, Gros, Maina, Johnson, & Adams, 2012; García, Peña-López, Johnson, Smith, Levine, & Haywood, 2010;

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Johnson, Becker, Gago, Garcia, & Martín, 2013) is bound to reach a high level of penetration into our educational centers as a whole, including universities, within a 3-to-5-year horizon.

This significance which AR has been progressively gaining becomes visible not only in the aforementioned Horizon reports but also in some other facts such as the following: Time magazine included it amongst the top ten technological trends of 2010, more specifically placing it in fourth place; and the Company Gartner Research, one of the world's leaders as far as Information, Communication and Technology (ICT) research and counseling is concerned, identified it as one of the technologies that would have a stronger impact in the coming years, with a use forecast in 2014 situated around 30% of users owning mobile devices. Another three examples of what was said above are: the Argentinian State educational portal *Educar* (http://recursos.educ.ar/) published a monograph about this technology in 2013; the journal *Computer and Education* has recently dedicated a monographic issue to it (issue 68, 2013); and specific sites devoted to it appear in the "content curatorship" of *Scoop.it* (http://www.scoop.it/).

Now then, what can be understood as AR and which could be the most significant differences with the so-called 'virtual reality' (VR)?

By way of summary, AR can be described as the real-time combination of digital and physical information through different technological devices; in other words, it consists in utilizing a set of technological devices that add virtual information to the physical one, consequently implying the addition of a virtual synthetic part to what is real (Fundación Telefónica, 2011; García et al., 2010; Muñoz, 2013).

In the words of De la Torre Cantero, Martín-Dorta, Saorín Pérez, Carbonell Carrera, & Contero González (2013, p. 5): "it is a technology that permit users' interaction with the physical and real world around them. AR combines the three dimensions (3D) of computer-generated objects and text superimposed on real images and video, it all in real time."

In short, AR allows the user to see the real world, in which superimposed or compound objects combine with reality (González, Vallejo, Albusac, & Castro, 2013). It is therefore a technology which mixes real elements with other added virtual ones for the purpose of creating a new a communicative scenography.

Di Serio, Ibáñez and Delgado (2013, p. 587) describe AR systems as being characterized by three properties:

— combination of real and virtual objects within a virtual environment;

— mutual alignment between real and virtual objects; and

— interactive implementation in real time.

It can be said that the aim sought with AR consists to some extent in enriching the information which exists in reality with the information available in technological devices. Expressed differently, when it comes to augmented reality, information resides in the real content; and the digital content only augments and completes it. "The concept of AR refers to combining what is not there with what does exist in an imperceptible way and offering users an improved or augmented representation of the world around them" (Mullen, 2012, p. 13).

As pointed out by Fundación Telefónica (2011, p. 10), its utilization somehow implies stimulating the physical senses of sight, hearing, smell, touch, and taste with a new technological sense that makes it possible to enhance and increase the information coming from the physical world. Based on this approach, García et al. (2010, p. 28) argue that it seems accurate to use the adjective 'augmented,' insofar as this technology amplifies human perception abilities, and permits to break down physical reality into its different dimensions with the aim of facilitating the capture of specific components which sometimes cannot be perceived through the senses, thus generating models which simplify the world's multidimensional complexity.

The considerations above allow us to establish a clear difference between AR and VR, since virtual data replace physical ones in the latter, as a result of which a new reality arises. Instead, AR shows two realities overlapping on different information layers in various formats (computer-generated images, video sequences, animations, etc.) in order to shape a new reality which is the one that a person truly interacts with. Anyway, it must be remembered that both 'realities' share a number of common characteristics, namely: immersion; navigation; and interaction (Dunleavy, Dede, & Mitchell, 2009; Kye & Kim, 2008).

This combination of real and virtual in AR requires bearing in mind that both real and virtual aspects play important roles when it comes to achieving an informative technological environment (Klopfer, 2008).

In the light of all that has been explained above, it comes as no surprise to check that AR has been acquiring certain importance during the last few years with a strong penetration into a wide range of sectors. Even though, as Fundación Telefónica (2011) has highlighted, a certain amount of time will still have to elapse before immersive AR arrives, our present-day AR can actually be described as simple, because it is accessible to everyone and allows us to carry out different types of experiments using easily available as well as user-friendly types of technological equipment such as laptops or mobile devices and, in our case, with an additional relatively strong presence both inside centers and amongst students. As a matter of fact, mobile devices appear as a kind of technology with a strong penetration into educational institutions according to the most recent Horizon reports (Durall et al., 2012; García et al. 2010; Johnson, Adams, & Cummins, 2012; Johnson, Adams Becker, Cummins, Estrada, Freeman, & Ludgate, 2013a, 2013b, 2013c).

Following the approaches put forward by various authors (Fundación Telefónica, 2011; Fombona, Pascual, & Madeira, 2012; Kipper & Rampolla, 2012; Mullen, 2012; García et al., 2013) different types of technologies are needed to produce AR environments, more precisely:

(1) An element which can capture images of the reality that users are looking at (a computer screen, a telephone, or a video console);

(2) A device to project the mixture of real images with synthesized ones (the three aforesaid devices can be used for this purpose);

(3) One or several processing elements that work jointly and have as their function to interpret the information from the real world that is received by the user, to generate the virtual information that each particular service requires, and to mix it in a suitable manner (computers, mobiles, or video consoles);

(4) A specific type of software for the production of the program;

(5) An activator of augmented reality or markers which can be QL codes, physical objects, GPS, amongst others; and

(6) A content server which hosts the virtual information that it is our intention to incorporate into reality.

Three types of AR presentation can be distinguished depending on the AR activator used: 1) position markers; 2) geolocation; and 3) QR codes.

In the first case, the process consists in associating a 3D image, a video, or an animation with a printed marker by means of specific software so that, when the marker is passed through the webcam, the virtual layer contained in that marker will be activated. As a result of this, if the marker perspective is changed, virtual objects will change their orientation, and that will allow us to observe their three-dimensionality. Software programs such as Aumentaty, BuildAR, and ARSights can be utilized for its implementation in teaching environments; these programs do not require owning a large amount of programming knowledge, and they make it easier for teachers as well as for students –in some cases– to produce resources.

The second case revolves around geolocation-assisted AR, its aim being to integrate AR technologies, GPS, visual search systems (CVS), and mapping (SLAM). Such applications offer users a framework for interaction with the urban system from their location at a specific point. Using the camera of their mobile device, users obtain a physical image of the place and a superimposition of information virtual layers that show those users a wide range of real data in real time about nearby establishments, history of the environment, events, etc. Different programs and applications such as ayar app, Hoppala, Junaio, Layar, Metaio, and Wikitude were used to carry out this task.

As for the third and last case, AR by means of QR codes, the interaction is perceived through two-dimensional square-shaped codes which permit to store a great variety of alphanumeric information that can subsequently be visualized using a QR reader installed on a mobile device; and it is through those codes that we can present the information.

Different programming languages exist too, including HITLab's ARToolKit, which has adaptations for various platforms, HIT Lab NZ's BuildAR, with proprietary applications for Windows, DART, a tool through which AR applications can be created with the Adobe Director programming environment, or PTAM.

A description and some technical references to the programs mentioned above can be found on the following web addresses: http://www.etwinning.es/es/ideas/herramientas-tic/749-realidad-

aumentada-en-educacion; and http://www.aumentaty.com/; http://reconstructme.net/.

In addition to these three levels, there is another one: that of augmented vision (Muñoz, 2013), the best-known referent of which is 'Google Glass,' even though different alternatives are already available on the market. Examples include: 'Epiphany Eyewear,' 'Mata,' 'Tele-parthy,', 'ORA-S,' or 'Glassup.'

However, from our point of view, the need for special devices will make AR incorporation into the educational sector –our focus of interest here– costly and belated.

2 EDUCATIONAL APPLICATIONS OF AUGMENTED REALITY

After defining it and once its basic characteristic have been commented upon, the time comes to ask ourselves: what types of application does AR have? And the answer could be that the different AR applications only have our creativity as a limit. According to various authors (Fundación Telefónica, 2011; Kipper & Rampolla, 2012), it is possible to use AR in a wide variety of fields: advertising, navigation and city guides, industry, art, language learning, travel and tourist guides, medicine, marketing and sales, entertainment and games, social networks, education, and translation.

As far as education is concerned, the first thing which needs to be highlighted is that different experiences and research initiatives related to AR utilization have recently been undertaken at various educational levels: primary education (Bongiovani, 2013); lower and upper secondary education/vocational training (Avendaño, Chao, & Mercado, 2012; Bressler & Bodzin, 2013; De la Torre et al., 2013; De Pedro Carracedo, & Méndez, 2012; Di Serio, Ibáñez, & Delgado, 2013; Kamarainen, Metcalf, Grotzer, Browne, Mazzuca, Tutwiler, & Dede, 2013; Liu, 2009; Pasaréti, Hajdin, Matusaka, Jámbori, Molnár, & Tucsányi-Szabó, 2011); and university teaching (LinT, Been-Lirn, Li, Wang, & Tsai, 2013; Pei-Hsun & Ming-Kuan, 2013; Redondo, Sánchez, & Moya, 2012; Rodríguez, 2013). Applications have been implemented in many different curricular areas such as: engineering (De la Torre et al., 2013); architecture (Carozza et al., 2012; De la Torre et al., 2013; Redondo et al., 2012); town-planning (Carozza, Tingdahl, & Gool, 2014), mathematics-geometry (Avendaño et al., 2012; Bujak, Radu, Catrambone, MacIntyre, Zheng, & Golubski, 2013; De Pedro Carracedo & Méndez, 2012); art and history (Ruiz, 2011); language learning (Emma, Liu, Tsai, Pei-Hsun, & Ming-Kuan Tsai, 2013; Liu, 2009); technology (Rodríguez, 2013); design (Ko, Chang, Chen, & Hua, 2011); chemistry (Núñez et al., 2008; Pasaréti et al., 2011); física (LinT et al., 2013); or geography (Klopfer & Squire, 2008; Tsai, Liu, & Yau, 2013).

Experiences have also been carried out with the aim of promoting students' positive attitudes towards science (Bressler & Bodzin, 2013; Ibáñez et al., 2014; Kamarainen et al., 2013), in training oriented to the acquisition of healthy habits (Acosta, Catalá, Esteve, Mocholí, & Jaén, 2006), as well as in the development of games meant to favor school coexistence (Pérez-Fuentes, Álvarez- Bermejo, Molero, Gázquez, & López, 2011).

Further examples of AR applications in educational environments are available at the monograph that Scopeo dedicated to Augmented Reality (Muñoz, 2013), or in the Horizon project reports (Durall et al., 2012; García et al., 2010; Johnson et al., 2013).

Within our context, the *Subdirección General de Coordinación Bibliotecaria del Ministerio de Cultura del Gobierno de España* [Vice-Directorate General for Library Coordination of the Spanish Government's Ministry of Culture] has incorporated AR technology into its libraries (http://infotecarios.com/yoshiocantarocalderon/realidadaumenta da-y-educacion-la-experiencia-de-un-nuevo-servicio-en-biblio-1). And an experience has equally been undertaken in the creation of the "*Libro Interactivo de Monumentos Andaluces* [Interactive Book of Andalusian Monuments]," where AR was applied at exhibitions and museums (Ruiz, 2011). Or the Estarteco project (http://www.estarteco.com/) developed by the Technological Institute of the Castile and Leon Autonomous Region (ITCL for its Spanish initials) with the collaboration of *Fundación Biodiversidad* [Biodiversity Foundation], in which an AR-based was developed which permits to appreciate the value of ecosystems, along with the complexity involved in ensuring their balance.

Likewise, a number of AR experiences have been performed with regard to the preparation of school books, including the 'Magic Book' project of New Zealand's HIT group (http://www.hitlabnz.org/index.php/research/augmentedreality ?view=project&task=show&id=54), or some primary education books of the Spanish publishing house Santillana within the series *Bicentenario 2011* of Argentina (http://www.santillana.cl/Bicentenario/index.html).

This increasingly strong presence of AR during the last few years has largely influenced the formation of different work teams focused on analyzing its technological development as well as the educational possibilities that AR can offer, both nationally and internationally. Amongst these groups and institutions stand out CREATE ("Constructivist Mixed Reality for Design, Education, and Cultural Heritage - http://www.cs.ucl.ac.uk/research/vr/Projects/Create/) and ARiSE. ("Augmented Reality in School Environments" http://www.ariseproject.org/) on a European level.

At a national level, there are quite a few experiences, institutions and research groups, such as the RASMAP ("*Plataforma de Realidad Aumentada sin Marcadores en Entornos Móviles para el Desarrollo de Asistentes Personales* [Augmented Reality Platform without Markers in Mobile Environments for the Development of Personal Assistants]") program, financed by the Spanish Education and Science Ministry through the *Programa Plan Nacional de Investigación Científica, Desarrollo e Innovación Tecnológica 2004-2007* [2004-2007 National Plan for Scientific Research, Development and Technological Innovation Program]; the 'Dehaes' research group from the University of La Laguna [Tenerife - Canary Islands]; the Castile and León Technological Institute. "*Realidad virtual* [Virtual Reality]". (http://www.itclimasd.org/Realidad-Virtual/); the EspiRA Project (http://ciberespiral. org/es/noticias/22-categoria-3-de-noticies/190-projecte-espira) which seeks to facilitate the incorporation of AR into the teaching world; the group known as "*Gráficos y Multimedia del Instituto de Automática e Informática Industrial* [Graphics and Multimedia of the Industrial Automation and Computer Science Institute] (ai2)" at the Polytechnic University of Valencia; the COMARFAREM work team that, amongst its aims, pursues to provide primary education teachers with AR-based educational platforms which can make easier their didactic tasks related to mathematics teaching (De Pedro Carracedo & Méndez, 2012); the MULTIMEDIA-EHU research group at the Higher Engineering School of the Basque Country (http://multimedia.

ehu.es/Joomla/); or the "*Secretariado de Recursos Audiovisuales y Nuevas Tecnologías de la Universidad de Sevilla* [Secretariat for Audiovisual Resources and New Technologies of the University of Seville], which is carrying out experiences oriented towards aspects such as: information enhancement; information enrichment; information integration into students' notes, 3D models of objects or real living beings, etc. which can be observed on the portal specifically designed for this purpose (http://ra.sav.us.es).

As for Latin America, several experiences deserve to be highlighted too, including the one performed by the "*Centro de Tecnología y Docencia de la Universidad de Concepción*" [Technology and Teaching Center of the University of Concepción] in Uruguay (CTED -http://www.innovacion.cl/2013/04/realidad-aumentada-en-educacion-la-innovacion-que-viene-a-las-aulas/); the "*Laboratorio de Investigación en Realidad Virtual* [Laboratory of Research into Virtual Reality]" of the EAFIT University in Colombia (http://arcadia.eafit.edu.co/); or the developments which are being carried out at the Open and Distance University of Mexico with the aim of optimizing the time invested in physical laboratories (García et al.; 2010, p. 28).

Nevertheless, prior to showing some of the results reached which can justify AR incorporation into teaching, it is worth bearing in mind that many of these experiences have taken place in laboratory contexts rather than in real and formal education contexts, that they are specific experiences, that a stronger emphasis has been laid on technological and instrumental approaches than on research initiatives focused on analyzing its educational possibilities, and that they have paid more attention to informal training contexts than to formal ones (Cheng & Tsai, 2013; Cuendet, Bonnard, Do-Lenh, & Dillenbourg, 2013; Di Serio et al., 2013; LinT et al., 2013; Wojciechowski & Cellary, 2013). To put it in another way, there is a clear lack of scientific research works and studies about the potential which AR can supply to training and the roles that teachers as well as students can play in that process.

After the considerations made above, the time has come for us to highlight some of the aspects which support the utilization of AR in educational contexts, with the aim of improving formative actions and making it possible for students to increase their learning levels through the creation of such technological scenarios. And, in this respect, one of the outstanding aspects is the fact that AR facilitates the understanding of complex phenomena and concepts. This is so because, on the one hand, it favors the breakdown of a phenomenon and/or object into its different phases, stages or parts and, on the other hand, it allows a perception of the object or phenomenon from various points of view (García et al., 2010). This combination of virtual and real aspects fosters its utilization as a means to replace the physical models which become so necessary in some artistic and scientific disciplines (De la Torre et al., 2013).

It is also worth stressing that AR scenarios contribute to make it easier for students to contextualize information, and simultaneously to enrich it with additional information in a variety of formats and symbolic systems, thus permitting to individualize training and to adapt it to the different types of intelligences and symbolic preferences existing amongst students (Fabregat, 2012).

Wojciechowski & Cellary (2013) refer to another of the possibilities that AR offers us for its use in formative contexts: thanks to it, students can directly and naturally interact with virtual objects through the manipulation of real objects –and

without needing to utilize sophisticated, costly devices. As shown by some research works, students interact with AR objects during the sessions, they show a high participation level, and also achieve a high degree of satisfaction with regard to the materials used, the chance to receive information in different formats, and the feeling that they have control over the activity, insofar as they could explore the topics in the order that they choose and may review the materials whenever they deem it necessary (Di Serio et al., 2013).

What has been said so far allows us to point out that AR can provide out-of-the-classroom learning experiences, and consequently favor the contextualization of learning, building links between reality and the learning situation in which students are taking part, thus helping to develop learning in real contexts (Bujak et al., 2012). In other words, any physical space can become a stimulating academic scenario from this perspective. For instance, Archeology, History, or Anthropology students could have at their disposal applications that reconstruct specific historical sites or three-dimensional maps and graphs that would recreate various historical moments. For this reason, it can be stated that AR favors ubiquitous and contextualized learning through the transformation of any environment into a learning environment (Fombona, Pascual, & Madeira, 2012).

Being able to count on different objects to enlarge the same real content encourages the connection and integration of various views about a single concept or object. This leads to create richer environments for learning, since the student is introduced into an immersive, enveloping context for training where no discrimination is made between the authentic and the real, and more information becomes available (Chen & Tsai, 2012; Dalgarno & Lee, 2010; Dunleavy, Dede, & Mitchell, 2009; Squire & Klopfer, 2007).

From our point of view, this contextualization allows students not only to acquire experiences but also to learn –through understanding– how the concepts acquired in the classroom can be applied to solve problems in real world situations. Within such contexts, AR helps students obtain a deeper appreciation of learning by relating the different learning contents to their own experiences.

AR-assisted educational practices favor active teaching on the part of the student, insofar as it is the latter that controls the learning process by making a decision about when that student needs to enlarge the information and to combine real and virtual aspects (Fombona et al., 2012). It can be said from this approach that AR makes it easier to develop a constructivist teaching-learning methodology, since every student becomes an active person, making their own discoveries through the establishment of a connection between the information that is presented to them by means of different channels and drawing their own inferences and conclusions; it all supported on specific teaching methodologies, of course. As pointed out by Wojciechowski & Cellary (2013), AR favors the implementation of a constructivist methodology, since the latter requires using interactive as well as dynamic learning environments where students can develop their ability to modify the right elements, to generate ideas for tests, and to carry out experiments; and all of this can be favored by AR incorporation.

At the same time, the physical movements performed by a student for object rotation and orientation change purposes facilitates the perception of spatial contents and objects in 3D, a fact that fosters the development of graphic competences amongst students (Redondo et al., 2012) and boosts the

mobilization of brain structures other than those developed by reading and writing.

Moreover, Schank, Berman, & Macperson (1999) –cited by Wojciechowski & Cellary (2013)– concluded in their research study that learning based on carrying out experiments and reflecting on their outcomes constitutes the foundation of practice-based learning. This paradigm suggests that the best and most natural way of learning to do something is by doing it –as stated in the theory of experiential learning. A strategy which increases understanding as well as the retention of learned material in comparison with those methods which exclusively imply listening, reading or even seeing, and it helps students have a greater motivation for learning because they actively participate in the learning process.

As far as the motivation aspect is concerned, it deserves to be stressed that all the research into AR which has envisaged it as a variable has proved that students who take part in these experiences increase their motivation, consequently enhancing their learning too (Di Serio et al., 2013). The same thing happened in those research studies which measured the level of satisfaction shown by students after participating in AR-assisted training actions, and presented their assessment of such actions. High satisfaction levels and extremely positive assessments were found in all of them (Chin-Ming & Yen Nung, 2011; De la Torre et al., 2013; Kamarainen et al., 2013; Ko et al., 2011; Neven, Hala, & Mohamed, 2011; Wojciechowski & Cellary, 2013).

Likewise, it must be highlighted that several studies have reached the conclusion that the immersion of students in AR-based training experiences led to an improvement in their learning outcomes (Bongiovani, 2013; Chang, Wu, & Hsu, 2013; Kamarainen et al., 2013; Ko et al., 2011; Liu, 2009; Pasaréti et al., 2011; Pei-Hsun & Ming-Kuan, 2013; Redondo et al., 2012).

Some of the comments made above allow us to insist on one of its possibilities –more precisely, flexibility– since it is our conviction that AR can be used on a wide range of educational levels, in different disciplines, with the possibility to implement it through a variety of levels, and using a wide range of technologies (Fundación Telefónica, 2011; Fombona et al., 2012). It must additionally be remembered that this technology favors different action levels, insofar as its design permits to create AR scenarios where the student exclusively acts as an information recipient, until they are designed in such a way that students can interact with it. This interactive potential appears as one of the great advantages that several authors have seen in AR (Bongiovani, 2013; Bressler & Bodzin, 2013; Dalgarno & Lee, 2010; Dunleavy et al., 2009).

One of the didactic methodologies which has been gaining significance in recent times is the so-called 'game-based learning' or gamification, because of the potential that it has shown when it comes to supporting immersive and experiential learning, as well as cognitive development, and the acquisition of aptitudes by students (Durall et al., 2012; Johnson et al., 2013c; Marín, 2012; Whitton, 2010). In this regard, AR is arising as a relevant technology for game creation, thus providing support for learning based on those games along with discovery-assisted learning (Fundación Telefónica, 2011; Bressler & Bodzin, 2013; Pérez-Fuentes et al., 2011).

Another educational possibility offered by AR is the creation of interactive multimedia contents, either through the construction of books especially designed under this technology (Fundación Telefónica, 2011) or through markers and object recognition (Mullen, 2012; Muñoz, 2013). Although the problem

that concerns us in this case is the low number of training experiences which have been developed –and therefore the shortage of scientific studies referring to how these materials should be designed in order to be incorporated into the educational practice.

Fabregat (2012) pointed out that the creation of AR-based interactive contents supports the learning process in various ways, amongst them helping in the acquisition of procedural knowledge which becomes essential so as to relate and understand the concepts learned by means of interaction with the resources which surround the individual –i.e. which makes the student form part of the real environment.

Another of the educational aspects which should be highlighted concerning AR is the association that various authors have been mentioning with the possibility of using it in distance training and e-learning contexts (Edel & Guerra, 2010; García et al., 2010). Thus, the Open and Distance University of Mexico has developed an AR project aimed at optimizing the time invested in physical laboratories dedicated to technological development plans which require certain cognitive skills. Or, as suggested by Fabregat (2012), the utilization of emergent technologies such as AR or mobile computing in e-learning environments so that a more personalized learning becomes possible and each student can progress at the pace marked by their own capabilities and interests. Furthermore, the aforementioned author points out that they turn out to be ideal for those students who require a higher level of exploration both about information and about objects.

The aspects that have been dealt with so far refer to situations in which students use AR materials produced either by lecturers or by technical teams; however, students can also become producers and designers of such media, the construction process allowing them to use those media as instruments to analyze the world around them, as well as to express themselves by means of all these resources. Media production by students, whether it is videos, multimedia materials, blogs or web pages, in accordance with the different research works already carried out (Chirinos, Vera, & Luque, 2013; Martínez & Hermosilla, 2011) has a number of advantages, namely: its highly motivating level, the contextualization of every message produced, the need to work collaboratively because this process implies undertaking various actions (drawing-up of a script, voiceover, software management, utilization of recording devices…) which require a coordinated distribution, an increased digital competence, an improved classroom atmosphere and environment, and a change in the teacher-student interaction. For us, the conception of ICTs as knowledge tools placed in students' hands will come from assuming it as a group-class working element through which it is pursued that the student can stop being a mere recipient of verbal-iconic codes to become an emitter of didactic messages.

This type of use favors passing from a student-centered teaching model to a student-centered one which, as highlighted by Fundación Telefónica (2012, 13-14) in a report entitled "*Aprender con tecnología. Investigación internacional sobre modelos educativos futuros* [Learning with technology. International research into future educational models]": "…implies considering that learning takes place through activities and questions generated from the student, and not from the teacher."

Nevertheless, a number of precautions need to be taken during its incorporation into educational action; after all, as Durall et al. (2012, p. 16) point out: "The main challenges for AR adoption in the teaching context lie in training and in the development of

methodologies which can help to make visible the potential that this technology holds for teaching and learning."

3   SOME FINAL REFLECTIONS

It must be highlighted that teacher training in ICTs has been recently based on the TPACK ("Technological Pedagogical Content Knowledge") model (Mishra & Koehler, 2006), according to which training teachers to use these curricular instruments requires the acquisition of knowledge in three broad dimensions: technology; contents; and pedagogical knowledge; though not in an isolated manner, as it has traditionally happened, but in interaction. This will allow us to suggest different training patters not only based on technology but also on the contents that the latter transmits.

From our point of view, the incorporation of AR into teaching situations makes it necessary to envisage several principles, such as: designing environments which are flexible enough to ensure that AR incorporation does not become a technological problem but an educational and didactic issue; assuming the limitations posed by the context; working with curricular contents for the purpose of achieving a penetration level that goes beyond merely marginal aspects, and enabling teachers as well as students to have sufficiently developed digital competences; doing research into the methodologies which can be mobilized within AR; producing multi-platform materials which can be used in various formats; and training the teaching staff in didactic competence so that they can incorporate AR into educational practices and use it to create scenographies that prove enriching in educational terms, and not merely beautiful from an esthetic and technological perspective. These are the aspects around which our research project will revolve.

The present paper is going to conclude with the remarks made by García et al. (2010, p. 29) about AR and its incorporation into education: "The possibilities that this technology can offer in higher education still remain to be discovered and depend on what we are able to imagine and devise as pedagogical applications rather than on the possibilities provided by the technology itself."

However, in our view, this must necessarily include doing research into the behavior of AR in teaching situations, and assuming that these are educational resources –unlike what previously happened with other technologies, which were presented as the 'panacea' that could solve each and every educational problem.

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