Augmented Reality as an Educational Tool of M-Learning Focused on Architecture and Urban Planning

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***Abstract*—This paper presents Augmented Reality as a tool for educational tool used for teaching of subject like history, chemistry or ecology as well as the original Augmented Reality tool centered on education in the field of the architecture and urban planning.**

Keywords—Augmented Reality; M-learning; hybrid urban space

I. INTRODUCTION

The use of augmented reality applications in education managed to get the educational classroom space, introducing within ubiquitous spaces where a specific area of education is no longer necessary, since we can have access to the educational space from any location, using last generation phones.

"Mobile learning (or M-learning) is defined as the type of education and training through mobile devices and is considered as a natural evolution of E-learning" as define De la Torre et al. [1]. The idea of learning with a help of the mobile devices arises in the year 2000, when Mike Sharples [2] publish a paper in the journal *Computers & Education*, showing a new designs focus on education through mobile technology, an evolution of E-Learning.

The advent of the Smart phones has created a massive use of M-learning applications, due to considerably increase of performance that mobile devices have acquired in recent years. In what refers to augmented reality applications, actual mobile devices are capable of performing a series of actions in real time:

-Display digital content in real-time
-Geo-location of the user
-Use of data stored in mobile terminal
-Live display in camera mode.
-Mixture of the all above mentioned characteristics

The completion of this series of actions by a single device makes possible skip the use of peripheral equipments. The use of mobile devices represents an ergonomic improvement in M-learning applications, by the use of sensors integrated mobile devices (GPS, inertial sensor, accelerometer, compass, Wi-Fi).

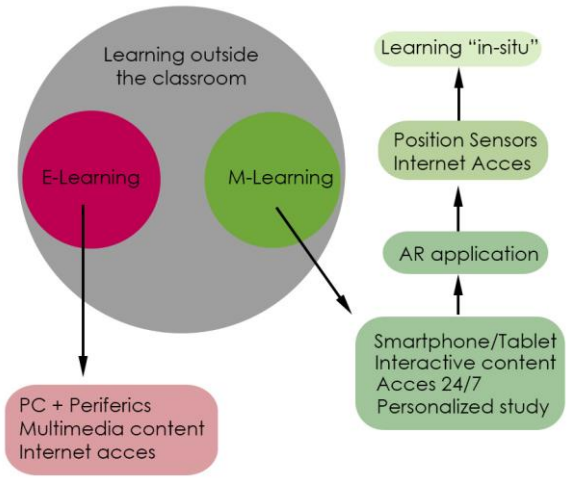

Figure 1. E-Learning and M-Learning educational space.

The main characteristic of M-learning is mobile learning by employing the mobile devices such as Smart phones that people carry on all the time. In recent years have thrived applications attempting to mix the mobile phone technology with augmented reality. Making available to the user the possibilities of access and interconnection with resources and users locate at web by definition of Zapata-Ros [3].

The education space is able to grow outside the classroom through the use of E-Learning and M-Learning. Through the use of M-learning and its implementation in the mobile phone, the user has access to education anytime, anywhere."Fig.1"

Pachler, Bachmair and Cook [4] present the three main features of M-learning:

a) The use of mobile devices, where students are applying the tools that offers mobile technology
b) The learning outside the classroom, by providing students with different learning situations
c) The need for student mobility, which gives the student the opportunity to learn or study at any times.

II. AUGMENTED REALITY RELATED TO M-LEARNING

The use of augmented reality technology oriented towards mobile phone in adaptive M-Learning environments, allows to focus the learning on a personalized level. The student himself / herself advances the study in his / her own velocity, interest and capacity. [5] Increase opportunities of the student by displaying an interactive layer which emerges around him. Which is able to guide him in the task completion and the study of new contents.

By using the augmented reality technology the educational process can be enriched with the virtual contents that remain invisible to the observer unless the some devices like Smart-phone is employed.

In educational environments, the use of augmented reality applications provides students with an additional layer of information about their environment, or a visual guide to the interactive performance of tasks affirms Donggang et al. [6]

"By combining mobile computing with augmented reality techniques, a great potential is created to provide contextual learning experiences and valuable exploration "*in situ*" and serendipitous discovery of information connected to the real world." affirms Gesa [7]. A new way to connect the space with content arises, as the didactic contents can be conditioned to the use of space.

There is a need of defining alignments and methodologies that can guide the creation of educational content based on augmented reality. Gesa [7] affirms that nowadays we are not disposed with such rules. With this kind of material would be possible to create custom content learning, getting closer to the learning "in situ".

The educational space is extended by the familiarization of students with new technologies, as it uses the degree of attention that students put into mobile applications. Improving communication in the teaching and learning, and relating it to the aspects of everyday life. To enhance this situation, it is necessary to design learning spaces where students can learn and participate in this technology space [8].

We understand augmented reality as an extension of reality that allows us to capture the virtual part around us, making possible to distinguish the digital information from our environment through a set of devices. If we understand the human body as an interface, which perceives the environment through the visual, auditory, tactile, olfactory or gustatory senses, we can understand the augmented reality as an extension that increases our sensory perception by a number of external interfaces.

In 1994 P Milgram and F. Kishino, termed the Continuum of Milgram [9], where they established a relation between a pure real environment (a direct view of the real world without the use of an electronic display) and a pure virtual environment (consisting only of virtual objects). Depending on the amount of digital information that is found between them, they called these intermediate states of the continuum as augmented reality and augmented virtuality, states where we find the connection between the real and the virtual.

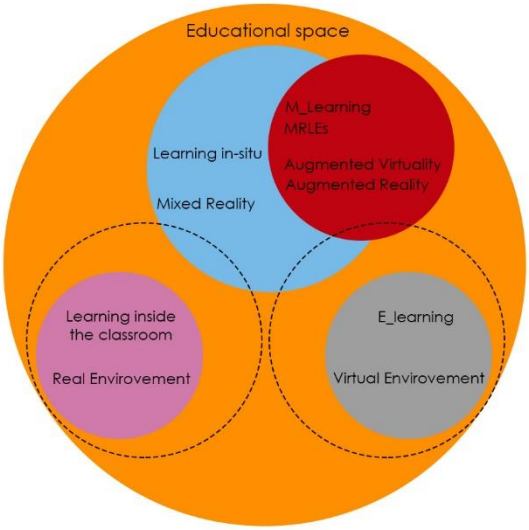

Figure.2. Real-virtual educational space.

Xiangyu Wang [10] moved the Milgram's continuum to the field of learning through *Taxonomy of Mixed Reality Learning Environments.* We find that the reality is related to learning in physical environment, education in the classroom, and part of virtual reality lies within the field of E-Learning.

As in Milgram's continuum, where intermediate environments are covering the mix of the real and the virtual, in which we place augmented reality, this continuum shows environments of Mixed Reality Learning Environments (MRLEs) able to delve into the virtual content within the physical world, creating new places for work and education, where the users can experience learning theories. Opening doors to a wide range of educational tools that allow us to increase the level of learning.

We relate Milgram's continuum to the educational space. Dealing as real space, the related one to the education inside the classroom, and the virtual space as the education E-learning, where all the knowledge is acquired by virtual means. In the space that is placed between both corresponding to the mixed realities we place the education "in situ", a type of education that can be given in any space or situation, where the M-Learning and the MRLEs are localized."Fig.2"

III. AUGMENTED REALITY APPLICATIONS FOR EDUCATION

Using augmented reality technology as a resource within the Information and Communications Technology, physical space, either through tangible interfaces focused on books, records and physical objects, or user's location, the M-Learning application found their use in diverse fields of education.

It is noteworthy to mention the areas where actually are emerging more M-Learning augmented reality applications that allow adapting forms of educational interaction to the immersive virtual world, and capable of linking the physical space with digital content that affect

it. We can divide the applications depending on various factors like didactic interactions and functions, thematic for museums and archeology and interpretation centers, didactic books to schools subjects, and application based on the location of the user.

A. Augmented Reality Application oriented at Museums

The augmented reality acquired an educational function in its use in museums, because it is able to create an interaction between the visitor and the exhibition in a new and educational way. Where visitors change their role from visual observer to active observer. The contents are displayed according to visitor interaction. The most important museums in the world like Moma, Prado, Tate, etc., use applications for mobile devices that besides being able to display the usual contents of audio guides and guided tours, are complemented by interactive contents linked to the artworks of outstanding importance.

We highlight the application Giovanna, developed by Itf. interactiva for Thyssen Museum Madrid. It allows users to access virtual information from the portrait of Giovanna Tornabuoni by Ghirlandaio, facilitating its vision with three different radiation image, x-ray, infrared and ultraviolet, unveiling the secrets used by the painter. A new way of rethinking the content offering new perspectives and experiences to the users.

The introduction of mobile telephony in all social contexts benefit the museums, now it is no longer necessary to provide museums with interfaces offered to the users, like audio guides. The trend is towards the use of the visitor´s own mobile device, in which the user can install applications, and increasing the degree of familiarity with the device. Making easier the task of displaying digital content and creating custom visits based on the time or type of content that visitors want to see.

B. Archaeology and interpretation centers:

We also found applications of augmented reality in education that focus on archaeological heritage. Using augmented reality to recreate the parts that no longer exist or have changed their appearance at some point in history, introducing educational content that refers to specific information in each archaeological site. Among applications of this type we highlight the "Create" (Constructivist Mixed Reality for Design, Education, and Cultural Heritage) project. This project allows users to modify the real / virtual space using existing elements in the physical world. Offering students to test their ideas, knowledge and experiences and explore the sites in a more interactive way. A new way which involves having a different access to knowledge and permits to create, rebuild and research in different historical periods. Intended to complete the archaeological sites where preservation has not been performed, but there is sufficient documentation for virtual reconstruction.

C. Augmented Reality applications designed to create educational books

One of the most used resources in the field of augmented reality in education is the realization of augmented books. These books use the images as augmented reality markers, allowing access to more information regarding the similar content. The virtual content appears superimposed upon the images. One of the most significant examples was created by the Human Interface Laboratory of the University of Washington, called Magic Book. This book reproduces the three dimensional contents and videos. Although it is not considered as an educational book, it represents the first book with these features.

Currently exists a lot of augmented books, all derivations from the same piece. Although the content changes performance is always similar to the Magic Book. In a commercial level exists a large number of publications classified as augmented books, oriented towards an audience aged between 7 and 14 years.

D. Augmented Reality applications focused on environmental education:

Project "APRENDRA" for high school students, developed by the group Graphics and Multimedia Institute of Automation and Industrial Informatics and Summer School of the Polytechnic University of Valencia, and the Technological Institute for Toys (AIJU) Ibi (Alicante). This project uses the augmented reality for the creation of educational games. Its first result is an application that lets you upload to iOS three dimensional content linked to augmented reality markers. These contents are related to the flora, fauna, and cultural heritage of Asia, Africa and America. The augmented reality is used as a didactic tool, capable of enabling familiarization of the students with virtual objects, animals or constructs, displayed through the application in a playful and interactive way.

Another part of the project is focused on the subject in area of Inorganic Chemistry. Viewing structures and forms, students can interact by using augmented reality markers, which permits a greater understanding of the manipulation of chemical forms.

The Massachusetts Institute of Technology (MIT) researched within the field of content creation with augmented reality technology related to education. As noteworthy example we can mention the "Environmental Detectives" application, an augmented reality multiplayer application aimed at high school and college students. This application designed as a game that operates in relation to the user's position, calculated by a Pocket PC that employs a GPS sensor in outdoors and wireless locator indoors. This educational game offers to students role play of environmental engineers, working in a situation where they have to find a toxic spill. Delves the students through a play in scientific knowledge arguments, offering the possibility of taking samples fictitious water and chemical concentrations. Data from these measurements are set according to the physical position of the user within the physical space.

Students are also provided with a multimedia database where they can find all the necessary information. This database can only be accessed from specific places where teachers collaborating in the project are located. This project serves to increase the capabilities of students in

organizational and logistical issues, due to the game time limitations of taking samples and reviewing the information from the database.

E. Augmented Reality applications based on the user's position

We also found augmented reality applications related to the user's position, we can highlight some applications focused on teaching astronomy, where the device calculates the position of the stars according to user's GPS location that facilitates identifying the names of stars and making possible viewing the stars at any time of the day, as in the case of application Skyview. The application also displays solar and lunar position, and can provide information on the location of the next sunset, or the path where the moon will rise.

Another application worth mentioning is Cosmosis1, created by Rich Blundell this application developed for iOS offers the view of the phone's camera through the different filters. It is an augmented reality educational documentary, where the user is guided through the creation of the constellations in the cosmos. The educational contents of this application were designed to be used in high schools and universities in science subjects, but it also serves to any user interested in this topic.

IV. VISIONARY CITY APPLICATION

In some areas of architectural education, we find that students need to imagine certain constructions, either because of the lack of graphic documentation or because the constructions were never realized.

For "Visionary City" application "Fig.3" we have created a type of highly interactive content, focusing on the augmented reality technologies that permit us to develop alternative learning models, where the environment becomes part of learning, allowing a better understanding of the concepts learned. This project was created by AR Group Manusamo&Bzika, formed by Alena Mesarosova and Manuel Ferrer Hernández.

A. Description and objectives

The project "Visionary City" represents the landmarks of architecture and urban planning of the world wide importance that remained in the phase of the initial idea or sketch, because of the technical difficulties that made them impossible to build in their era. These ideas were often reflected in the designs of architects belonging to later generations. The application displays and familiarizes us with a free interpretation of the most original and futuristic projects of the French neoclassical architect Claude-Nicolas Ledoux, the experimental architectural group Archigram and architect Ron Herron, and the innovative ideas of the French architect and urban planner Yona Friedman.

In this application we recreate the visionary space by constructing virtually these never build ideas and superimposing them upon the existing urban environment.

We enter in this manner to augmented urban space, "the physical space overlaid with dynamic data," according to Manovich [11]. This environment characterized as a new type of physical space, could not be ignored any more as the virtual information surrounds us. As authors Aurigi and DeCindio argue [12] "the virtual space and physical space no longer represent two opposite elements but form two parts of a whole."

In this sense the "Visionary City" application represents a new kind of educational augmented urban space, offering the virtual contents with the educational purposes. In this application the interpretations of architectural ideas and urban programs were completely created in a three-dimensional virtual environment. The virtual models were positioned by using the Augmented Reality technology in an augmented educational space, located in the exterior campus of the Polytechnic University of Valencia. Making it in this way more accessible to the students of architecture.

One of the objectives is the education "in situ", education out of the classroom in a geo-localized environment. An environment that in spite of finding itself inside an educational space is destined the recreative functions, being the most opportune place for an interaction in the social level extending it in the context of the virtual educational interaction.

The application consists of several levels and has a simple and intuitive interface which facilitates better understanding by the students. In the main level can be visualized the three-dimensional models, which are interactive and in some case also animated "Fig.4", as in the example of interpretation of futuristic project named "Walking City" sketched by Ron Herron and Archigram experimental group. The virtual models are superimposed in real physical space and displayed on the screen in conjunction with live video stream from the integrated camera of the mobile device "Fig.5a", whether Smart phone or tablet is used. In this way it is possible to walk

Figure 3. Visionary City Application title screen.

Figure 4.Screen-shot of the three-dimensional models of mega-structures, superimposed upon a real environment.

through the parallel city passing by the spherical Ledouex´s house “Maison des Gardes Agrícoles” “Fig.5b”, or underneath the utopic Friedman's “Ville Spatiale”.

By including the GPS position the application permits to observe these unusual constructions from different angles, as the user moves along the street in the real urban space.

The virtual models are aligned within the physical environment by tracking function of the of the Augmented Reality application that allows to position the virtual content always at the same coordinates in real space. The virtual models that represent mobile architectures are animated and change their position according to a trajectory previously defined in the real space. Mobile models are accompanied by an audio effect a characteristic sound that changes according to the distance between the virtual model and the user.

The information on the models can be displayed simply by touching them on the screen, which leads to a level descriptions and offered us a choice of wider exploration of the topic through Internet links ”Fig. 6”.

As it is an application that is a representation of an educational augmented space, we have integrated more types of levels. The application offers the opportunity to verify the level of knowledge was acquired by using a brief test on selected items, so the user can self-evaluate the level of knowledge in these subjects ” Fig. 7”.

B. Development process

In the initial process of development we have selected the contents according to several criteria. The most important criterion was to choose the projects and ideas that remained in the phase of idea or a project as well as the originality and further influence to architecture evolution. Virtual representations were modeled by using Blender, an open source software, that permitted us to produce the three-dimensional model, a free interpretations inspired by the original sketches of the architectural ideas. The process continued by texturing the models, and “baking” the final textures for more optimized performance of the applications. The models that possess the characteristics of the mobility were animated also using the Blender software, the animation simulates the movements of the urban mega-structures, which can be observed in the real world, by displacing of the models and movement of the certain parts of the models. The application for mobile devices was developed using several SDK (software development kit), which enriched it with augmented reality features and physical world material behavior. The application for its correct operation needs to be installed on a mobile device with an integrated camera, GPS and an Internet connection. The most of the users of “Visionary City” found very interesting the fact of being able to learn about parts of the history of architecture that previously could not observed. Especially the fact of being able to visualize these urban structures in a real world scale. Before the test with users “Fig.8”, we had the doubt that the scale could not be managed to understand because of the fact that the models were visualized through a screen of a mobile terminal, in a view of its limited size. After consulting with the users, the perception of the scale of the virtual contents of great format they had experienced, was the one of the things in that they had been interested in and valuated very positively.

Figure 5a. Visualizing superimposed virtual models upon a real environment by using a Smart phone.

Figure 5b. Screen-shot of the superimposed model of the “spherical house”.

Figure 6. Description level.

V. CONCLUSIONS

Augmented reality technologies open a new educational space in which learning is mixed between the real and the virtual environment. They allow the user to experience out any spaces, indoors and outdoors, offering the possibility of extending the learning space, space and the E-Learning got out of the classroom to explore the personal space of students, now with the M-learning arrival, and the use of mobile platforms have been possible to implement Mixed Reality Learning, which have enabled augmented reality end to enter the education field.

Figure 7. Knowledge test level.

Figure 8. Test of "Visionary City" application with the users.

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