Architectural Geo-E-Learning

Geolocated Teaching in Urban Environments with Mobile Devices: A Case Study and Work in Progress

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Abstract. This work addresses the implementation of a mobile Augmented Reality (AR) browser on educational environments. We seek to analyze new educational tools and methodologies, non-traditional, to improve students' academic performance, commitment and motivation. The basis of our claim lies in the skills improvement that students can achieve thanks to their innate affinity to digital media features of new Smartphones. We worked under the Layar platform for mobile devices to create virtual information channels through a database associated to 3D virtual models and any other type of media content. The teaching experience was carried out with Master Architecture students, and developed in two subjects focused on the use of ICT and Urban Design. We call it Geo-elearning because of the use of new eLearning strategies and methodologies that incorporate geolocation, allowing receiving, sharing, and evaluate own-generated student's proposals, on site.

Keywords: Augmented reality, E-Learning, Geo-Elearning, Urban Planning, Educational research.

1 Introduction

Augmented Reality (AR) technology is based on overlapping virtual information in real space. A framework where technology could be potentially more interesting is the representation and management of the territory, because real scenes could be "completed" with virtual information, which would facilitate a greater awareness and better understanding of the environment. In the field of architecture, for instance, AR allows new buildings proposals visualization, and their impact assessment, on its planned site. To do that, a Geographic Information System (GIS) is needed to provide and manage and filter public queries with different levels of accurate and upgradeable information. In short, we need to link a 3D model to a database which contains all the necessary information associated with it. This process has been the first target of this work.

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Furthermore, the introduction of new learning methods 3.0 and new collaborative technologies, besides the new ways of information access via 3G phones or tablets, offer new opportunities to provide educational multimedia content. New representation systems and management tools are getting closer and easier to use. As part of the architectural or urban planning, these systems provide new tools for the representation of architectural forms and related content. In adition to this capabilities, cloud computing thechnology which allows sharing applications and services via Internet at any time, generates a workflow where teaching experience becomes a new paradigm of training processes and contextual learning. The evaluation of a methodology focused on the training of architects and planners is the second objective of this investigation.

Our proposal involves methodological changes which include information management through GIS technologies, visualization using RA, and all types of mobile devices interaction. A free application that support all this features is Layar© by SPRXmobile©, initially designed for tourist information. In our case, we used this platform because of its compatibility with all mobile operating systems. Registration of virtual information is based on the use of GPS, which is accurate enough for outdoor environments.

The teaching experience, that was performed to validate the previous premises, arises at Master level subjects. They involve the use of ICTs applied to the analysis and territorial representation, where 3D GIS systems, 3D modeling, and Urban Virtual Reality are combined. The proposed approach is based on the use of smartphones to incorporate virtual models generated by the students in an existing AR platform to view them on site, through their own mobile devices. We tried to promote new learning strategies for sharing, collaborating and transmitting information to other participants. To address the process scientifically, we developed a case focused on large-scale urban projects, in particular on the campus BKC (Barcelona Knowledge Campus), University of Barcelona (UB) and Polytechnic University of Catalonia (UPC).

2 Framework. ICT 3.0. Geo-Elearning

Currently, ICT technologies related to Web 2.0 environments, such as RA or Geolocation, besides mobile devices popularity and their recent advances, open new prospects in Mobile Learning (ML) [1], a specific field of E-Learning (EL). Thanks to this new approach, it is now possible to design teaching activities where student's queries about a particular site are facilitated to share information, experiences, and content, most of the time, own generated. It is known as Web 3.0. These methods can generate extra student's motivation because of the use of their own devices in real environments [2]. Smartphones GPS integration in education [3], and 3D data visualization in outdoor environments [4] has been already tested. In the case of urban planning [5] [6] as well as historical heritage, we can find systems that link graphical information systems with databases, as assitance tools for interpretation and information compilation. Other studies discuss the proper integration of spatial data from different sources

[8], they mostly rely on information mapping and the use of conventional GIS [9]. But, those systems do not usually use AR techniques to geolocate information, and they merely generate a model from photographs or by the use of laser scanner techniques. These projects neither deal with database maintenance and queries filtering, in real time, nor by the implementation of AR in teaching environments.

On the other hand, the emergence of web-based 3D globe viewers with elevations, satellite and aerial images, maps and 3D features, such as Google Earth© or Virtual Earth©, has promoted the exchange and visualization of geo-referenced 3D models in a natural way. Despite its shortcomings, success of these visualization tools is greater than traditional 3D globe viewers based on VRML and X3D [10]. Moreover, the use of an RA urban planning systems to allow consultation through mobile devices, as intended in our trial, has been reported recently [11], [12], [13]. Other authors [14] investigated the use of smartphones as a tool for public participation in urban planning projects. But research addressing these issues is still poorly documented. The introduction of more user-friendly technologies (such as mobile phones, tablet, social networks, etc.), in the learning process, is an educational strategy that removes the traditional and bored lectures. In this case, it helps to address the problem of urban 3d models design, its georeferencing, its consultation and its assessment on site through mobile devices dynamically.

3 Teaching Context

The experiment was carried out by 11 students of Architecture and Planning, in an elective course called "ICT applied to Spatial Analysis", which is tough in the Research *Master in Land Management and Valuation* of UPC, Barcelona-Tech. We worked within the scope of BKC, during the academic year 2011-2012. Total course duration was 60 hours. This method is currently being replicated (during 2012-2013), in the *Master in Processes and Graphical Expression in Architectural Urban Projection*, in the Center of Arts, Architecture and Design (CUAAD, Universidad de Guadalajara, Mexico).

4 Methodology

4.1 Modelling, Geolocation and Virtual Models Visualization

We have started from BKC contents, in particular, documents and planimetric images provided by the authors of the project. Each student should have a mobile device equipped with camera, GPS and 3G connection, and was required to download the free browser *Layar Viewer©*. The process aims to incorporate virtual models generated by students in a mobile application and view them on its planned site. To do this we used a Geolocation-based AR application which uses GPS, compass, and other sensors in the student's mobile phone to provide a "heads-up" display of various geolocated points-of-interest (POI's). In this case, student's Architectural proposals placed on the campus. Students worked with Sketchup© and 3dsMax©, to perform volumetric models and textures design, using real building materials. Secondly, they were divided into different groups A, B, and C. Each group modeled three proposals with the information provided, according to the preset numbers, and set coordinates origin at point 0,0,0 of the modeling program. Then models were exported to *.Obj format, and they were imported from the LayerModelConverter© (LMC, easy installation and free) program, which generates a specific file to be readed by Layar viewer. In addition, UTM coordinates should be recorded to be associated to the model in the database. In order to avoid problems, in this point, students should control the export path, check the units, activate the texture maps and change all YZ coordinates.

Previously an information channel was generated as a developer in the layar platform. The channel was published using BKC basic information and was configured to allow the use of filters. Comprehensive filter settings helped users to find POIs that were interesting easily, and to separate proposals by groups. Database and PHP file was hosted in a public server with PHP, MySQL, Java, support.

Meanwhile, students have installed Layar© RA browser, in their mobile devices. Once installed students were required to locate the particular channel created. In this case, it was located within the category of geo-layers of architecture and buildings, named "Tesis_Albert_app". Students proceed to filter by groups the architectural proposals. In our experiment a group of students evaluated the models of the other groups. The query is sent to the server host, which returns the selected POI. They are shown in the screen superimposed to the real image captured by the camera. As we approach or focus on one in particular, at the bottom of the screen appears a label with the model reference information and distance from the user. Clicking that label, students can acces to questionnaire "iweb" to respond and make comments about appearance, impact and scale of the building.

4.2 On Line and Contextual Questionnaires Design

The next step to complete the "on site" learning process is the contextual questionnaires design, which ought to be answered by students once they had located all proposals generated by different groups. The questionnaire is accessible through a descriptive label in the device display or by pressing on virtual buildings models. We have proposed two different questionnaires: in the case of existing buildings, students can access to questionnaries about the use of technology and system usability assessment, according to a standardized methodology for these experiments; for new buildings, students evaluated and reviewed all information linked to them (Fig 1), as project plans, memory, or project rendered views, which provided aditional insights. In addition, students should choose the best viewpoint to appreciate the integration of the new project with the existing building.Personal responses were sent directly to the teacher who received and analized the information.

Fig. 1. Design and implementation process of on-line contextual questionnaires used in the experience. Source: The authors.

4.3 Case Study

The students have different profiles (they came from 5 different countries, and different disciplines andeducational areas): from Latin America, to Saudi Arabia, most of them were architects from countries where planning and compulsory computer training is not included.

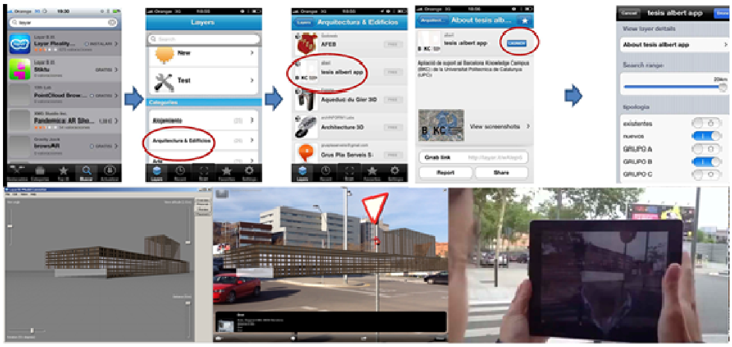

Fig. 2. BKC projects on Layar platform. Feasibility Study of “on site” visualization methodology for 3G mobile devices. BKC projects on Layar platform.

They were divided into three groups: A for existing buildings, and B and C for new buildings, according to planned campus project. They modeled three buildings for each group wich were coded as folows: B1, B2 and B3, C1, C2, and C3. Depending on their computer skills students worked in pairs or individually. They developed the projects assigned in three sessions of four hours each. Once modeled, proposals were geo-referenced, and teachers proceeded to export and upload all generated information to the database that feeds the channel. In the last session, all groups made a guided tour through the campus, where Student’s Architectural proposals were located, tested, and evaluated. Since not all students had 3G phones, they were pooled to make the experience, even with the phone of another partner.

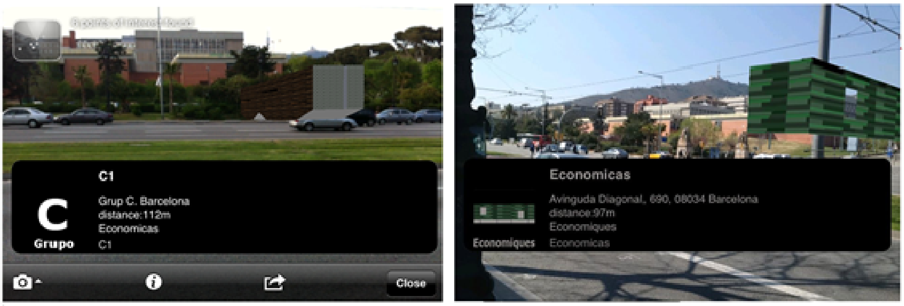

Fig. 3. Sample images of projects from BKC visualization “on site”

5 Results

5.1 Results in the Case Study on BKC

The experience was innovative: 100% students were able to complete the exercise, so they could visualized on site their proposals. Using their mobile devices and geo-locate information, they evaluated all buildings from differents groups. Although GPS accuracy was poor, as expected, both the application of semitransparent textures and the object visualization at a distance, allowed the recreation of a scene true enough to score the proposals and assess their visual impact. Buildings, displayed in their planned site, were assessed using issues such the scale, color, location, heigh, etc…

Questionnaire responses were used as a mechanism to verify student’s participation in the exercise. Results showed student’s high degree of satisfaction in relation to the activity, and the course contents. The self-assessments about the interest and usefulness of the technolgoy were useful to get an idea of the high level of acceptance achieved.

6 Evaluation

To validate the experiment, we conducted a usability questionnaire as detailed above; in the same way we did in other experiments of this R&D project. The questionnaire is divided in three parts: Personal training and prior knowledge about the technology; Teaching content and course material opinion; and finally, AR technology and software used.

In relation to students personal training and the prior knowledge level of the technology, should be noted that the most often used applications were "Email" and Computer Aided Design (CAD) applications, followed by "Internet browsers" and office applications. The most used operating system was Windows and the less knowledge resulted in LINUX and AR systems. (Scale: 0 = none, 5= advanced). Similar data was obtained from other ICT courses evaluated. Note the high punctuation in CAD applications, possibly because students are on their final phase of their training as architects. Global opinion was rated very positively at the end of the course despite the prior ignorance of AR technology.

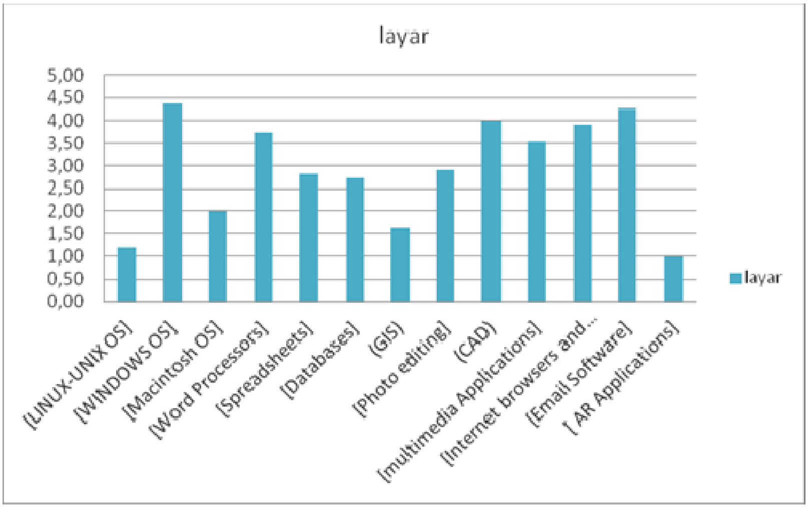

Fig. 4. Average results about personal trainingthe and prior knowledge of AR Technology

Related to the opinion, teaching content, and material of the course, there should be noted that it was very high rated. Material representativeness and the number of exercises in accordance with the objectives were optimal. The final average rating was more than 4.00 out of 5 points (Fig. 5). The worst rated question was referred to the possibility of learning such content independently. Software used was also low rated, probably due to the registration inaccuracy based on GPS.

And related to augmented reality technology and software used, 100% of the students found them useful in the field of architecture and building construction, despite having no prior knowledge of it. Final assessment was 4,27 points out of 5.

In a correlation analysis between the course global opinion and the other variables, a high correlation (0.69) was detected with: the representativeness of the exercises and the quality of the presentation. So these variables are crucial to the success of this teaching experience. Not being so correlated with the fact of being able to solve the exercises independently or with the number of exercises proposed. The strongest correlation (0.86), however, was in the use of appropriate software, and this is, therefore, the most important variable to consider in future work. Variables related to prior knowledge of technology and the use of different software and operating systems were not significantly correlated with the overall opinion of the course.

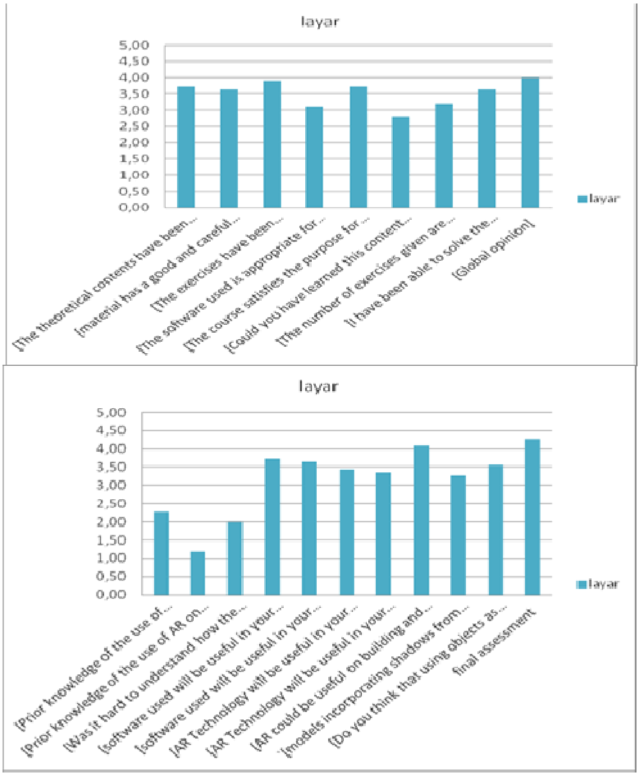

Fig. 5. Top: Rating table about global opinion, content, and material of the course Layar. Botton: Rating table about technology and software used.

7 Conclusions

We've tested the use of new mobile AR technologies in a master's program in architecture as a complement to other experiments. They had been carried out in first and second cycle courses of graduates in the European Higher Education Area (EHEA). In this case, the experience was performed within a larger framework of a R&D project. Thus we've completed an initial assessment in all training levels of architects and planners.

The ability of spatial representation of AR technology has been assessed in models of different complexity and level of realism. The processes to generate and visualize models have been also optimized to suit the capabilities of 3G mobile phones. Moreover we evaluated the ability of spatial location of the Geo-location technology integrated on mobile devices.

Geo-location, RA, and mobile technologies, used in the teaching processes, improve student's academic performance. They allow reducing learning and response times by the student. The teacher, in turn, can extend the learning process anywhere at any time. However, architectural models generation with AR is sometimes complicated and of poor quality in most application. Probably, due to the geometry simplification to reduce the number of triangles to be processed. To counter this effect and to achieve realism in the AR scene is necessary to use lighting simulation techniques to be applied in textures.

This difficulty is lower for higher level students, master's or postgraduate, as they have better computer background of 2D drawings, 3D rendering, and image processing required in these processes. On the contrary if they have no previous experience is better to use high usability programs like SketchUp with special plugins for them. Geo-location of architectural models using 3G phones based on GPS is poor, and only feasible to be seen at a distance of over 25 meters. Therefore we can conclude that these technologies are becoming accessible and easy to use. They increase student satisfaction and interest in the course content as they feel very motivated and are regular users of mobile devices.

In reltaion to the second experiment that is being replicated in the CCU of the UDG, Mexico, we are currently awaiting final presentations of student work to be evaluated. For now, we can say that the number of students who participated in the experiment was 26 and only 41% were able to develop all practices.

Fig. 6. Visualization process on site, of various projects of the CCU Convention Hotel, UDG. Source: The authors and Masters students.

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