ARSK: an edutainment application using augmented reality for basic education children to strength the knowledge of the human skeleton

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Abstract. At the moment, the quality of education in Mexico is considered as poor, many basic education students do not reach the goals set at the study programs. Given this situation, it is necessary to develop strategies to strengthen the teaching-learning process in basic education. The use of technology in education represents an important factor in achieving those purposes. For years, the introduction of technological devices, as support educational tools, has proved significant benefits increasing the level of students learning. Moreover, with the development of new technologies such as mobile devices, this effect is even greater. The present work focuses on the development of an educational application for mobile devices. This tool is developed as a support for the learning of the bones of the human body by students of third year of primary school, in the natural science subject at school. We use augmented reality (AR) with the aim of improving the student experience and strengthen the educational concepts taught in the classroom. AR allows blending real world images with virtual objects, modeled with the use of tools for creating three-dimensional (3D) graphics. The results show that children could improve their knowledge with the help of the application. Usability testing results reached a user satisfaction of 93%.

Keywords: augmented reality; 3D models; edutainment; smart phones; virtual reality

1 Introduction

According to studies published by the Instituto Nacional para la Evaluación de la Educación (INEE), there is a low quality of education in Mexico [3]. Despite the undeniable progress in the education, this is not enough; basic school students exhibit low levels of learning and do not reach the goals set by government programs in public institutions. On an international scope, the situation is even worse: 15 years old young Mexicans have by far lower levels of competence compared to the youth in developed countries. A considerable proportion of these students do not reach the minimum necessary to pass proficiency tests. The sources of these problems are usually the lack of attention by students, but also the problem lies in the learning methodologies used [28]. To address this problem it is unavoidable to find alternatives for strengthening the teaching-learning process in education, and the use of technology is a good option.

The application and use of Information and Communication Technologies (ICT) in various fields in education is growing [9]. The introduction of technological devices, media and general ICT as educational support tools have demonstrated significant benefits in increasing the level of students learning, especially with the development of new technologies such as mobile devices. The popularity of mobile devices has increased [20], and now it is common that most people have access to them, including children and youth. The acceptance of these devices is mainly due to certain characteristics such as portability, cost, and ease in handling. New generation mobile phones have more uses than communicating; they are used as means of entertainment, a feature that can be exploited for educational purposes.

There are many applications focused or developed to support education, such as games, collaborative systems, etc [13]. This will enhance the user experience and increase the use of systems. This paper describes the development of a learning support tool, which is the first step of a project to develop educational applications for mobile devices. As a case of study, we address the issue of the bones of the human body as part of the curriculum of the third grade in the natural science subject, according to the educational programs of the new Reforma Integral de la Educación Básica 2009 [4].

The purpose of applying AR in education is to enhance the student experience as well as reinforce concepts and knowledge acquired, as shown in [14, 22, 23]. AR is an emerging technology that allows us to generate 3D virtual objects, juxtaposing these objects on a real life scene in real time.

The aim of this paper is to incorporate AR as a teaching resource for education, seeking to reinforce the concepts discussed in our case study. Next section describes the pedagogic fundamentals, which specifies the topic that follows and which level address the issue of the skeletal system, as well as the expected learning. Section 3 deals with the techniques for the modeling in Blender and especially those that are employed to develop this project. Section 4 justifies the use of mobile devices. Section 5 discusses the issue of augmented reality, how it works and the benefits it provides when is used in education. Section 6 shows the results of usability tests of the system, and conclusions can be found at the last section.

2 Pedagogical Foundations

In Mexico 77.4% of students are registered in basic education: preschool, primary and secondary school [6]. Primary school is quite important, as at this level students develop their thinking skills. Although efforts have been made, basic education in our country remains in a poor state [7]. The government has launched projects to improve education, as mentioned in [8, 10, 5]. Thus, these projects seek to interpret and to communicate phenomena, concepts, processes or procedures from several points of view and assess the relevance of the results with appropriate pedagogical mediation, ensure better training processes [8]. The field of natural sciences at basic education is where students reach the highest percentage of performance (scores place them just 25 percentage points of achieving mastery of the issues set out) [2]. These results may be explained by the learning from daily contact with natural phenomena. Within the contents of third year, the least dominated topics in the area include: functions, care of human body systems, natural resources and their protection, as they are involved with improving quality of life. The main interest of addressing the issue of the human body is to strength the childrens knowledge on the osseous system

3 3D Modeling

A 3D model is a graphic representation of an object or entity within a three dimensional space (x, y, z). There are many ways to build a 3D model, from the use of OpenGL directives up to the 3D design tools. By using directives of a programming language like OpenGL, yields a model that spends less computing resources while rendering. But a more complex model requires a lot of effort to design it. Using a 3D design tool is possible to create complex models in an easier way and wasting less time. This implies that this model must be exported for using it in final applications, therefore rendering needs more memory space and processing resources.

We decided to use a 3D design tool, since the used models must provide the greatest possible realism. We opted for Blender [1] because it is a free, robust and popular tool.

The main modeling technique used was rotoscoping [24], which consists in shaping a 3D object using at least two views (front and lateral). These views are used as background images in the 3D design tool (see Figure 1), then a primitive whose shape is close to what you want to model is chosen (see Figure 2).

The technique of polygon mesh modeling was used to shape the primitive [15] (see Figure 3), it consists of selecting certain vertices and placing them on the outline of the background image (see Figure 4).

Once the primitive has the outlined shape of the views used to model the object, it is necessary to add details to shape special parts that bring relief or cavities, using boolean operations modeling [15].

The eyes cavities were then created using shaped sphere primitives (see Figure 5). Then, we applied boolean operations to create the cavities in the skull, obtaining the desired effect (see Figure 6).

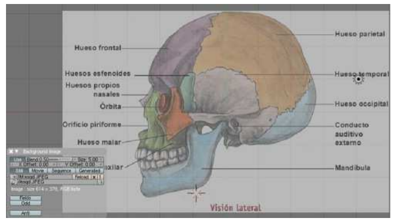

Fig. 1. Lateral view of a skull

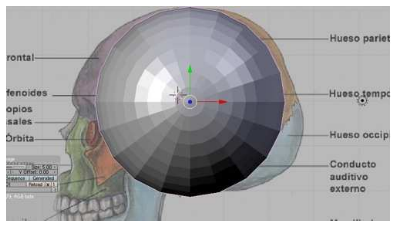

Fig. 2. At the background, lateral view of the skull. At the front, the primitive (sphere) that will be used to model the skull

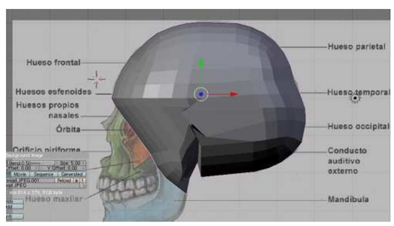

Fig. 3. Lateral view of skull

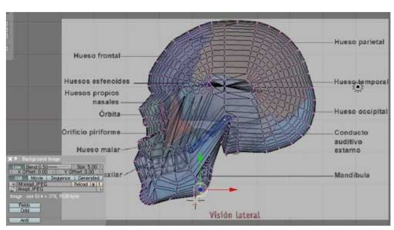

Fig. 4. Lateral view of skull

Finally, once the 3D object model has all the necessary details (see Figure 7), we applied NURBS modeling [15] to give a more organic or bent appearance (see Figure 8).

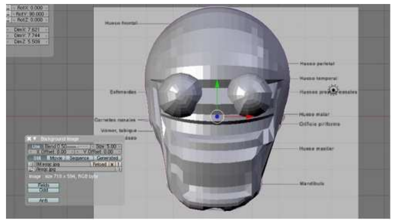

Fig. 5. Adition of shaped sphere primitives to create the eyes

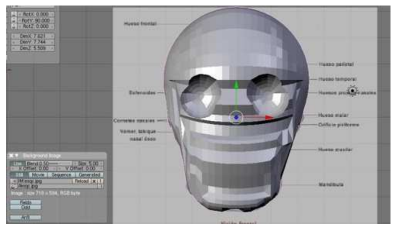

Fig. 6. Modified skull after applying boolean operations of subtraction to get the cavities of the eyes

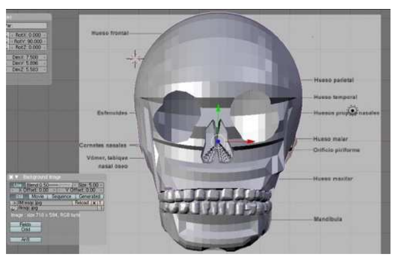

Fig. 7. 3D skull model after adding details off eyes, nose and teeth

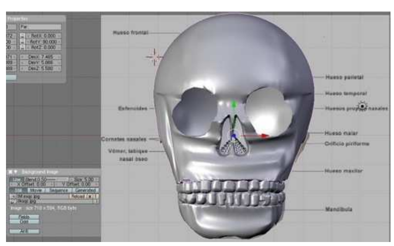

Fig. 8. 3D skull model after applying NURBS

4 Mobile Development

There is not a widely accepted definition of what a mobile device is, but it can be considered as a microcomputer that is light enough to be carried by one person,

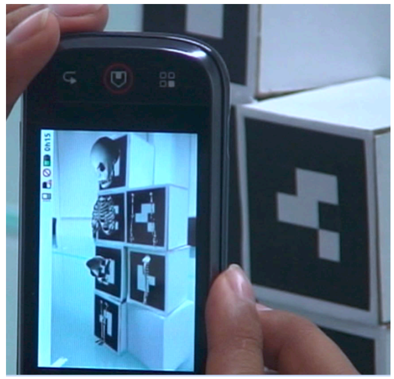

Fig. 9. Application running in a Motorola Dext smart phone

and has the ability to be operated autonomously [27]. The use of these devices is in contestant growing; as a parameter, last year sales increased 13.8% [20] and smart phones grew 19.0%. The most popular Operating System (OS) is Symbian, but the one that shows the biggest expansion is Android (3rd most popular), forecasts predict that Android will hold the first place by 2014. Android is an open source OS for handsets developed by Google and the Open Handset Alliance, based on Linux kernel. Android provides its own Java framework suited for a fast mobile applications development [19].

The use of mobile devices in fields like education is growing because of their capabilities (computational resources, sensors, cameras, etc.), and the variety and quality of novel educational contents [21]. Thereby we used a mobile device (see Figure 9) with an Android platform.

5 Augmented Reality

AR is a technology derived from Virtual Reality (VR) which allows the users to add virtual objects over a real stream letting the users to interact with them as if they were real. 3D models are used in most of cases, but it is not a compulsory requirement [11, 25]. In other words AR is the result of combination of virtual objects generated by a computer and the reality as seen by the user, thus a real time mixed reality is created. Unlike VR, AR combines real and virtual objects, whereas VR substitutes real-world features for virtual items.

During the present decade, AR has been widely used in educational environments, developments have been towards didactic material, which offer more realistic experiences than images or static contents [12]. Through AR techniques, a more diverse content can be added to treat complex concepts inside the classroom, ought to these concepts in the real world could be dangerous or expensive.

A useful AR features in education is [18] as it attracts attention because there is a direct manipulation of objects and encourages teamwork. Like most of

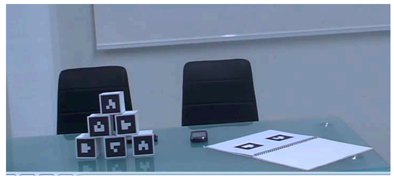

Fig. 10. On the left, cubes with printed marks for team tests. On the right, the bones album

new technologies, AR has the power to attract the attention of students by creating more complete and constructive environments, which stimulates learning and encourages involvement in the process of knowledge discovering by themselves [16, 26]. Other important features are that using the hands, it is possible to interact with the model, yielding a richest experience; it is possible to support teamwork because unlike the use of computers on which a working group directs their attention to the screen, using AR, students can concentrate on the model and interact with it at the same time. Another kind of possible manipulations of virtual objects are zooming in or out, changing of colors or textures and rotations [14, 17].

Overall, the AR scheme is: a camera captures reality that will be the modified to create the virtual scenario. Special marks or patterns are identified by processing the real stream, once identified such patterns the next step is to load and display a predesigned 3D model inside the real stream. The 3D model can be modified as mentioned in the preceding paragraph in real time and displayed inside the modified stream creating the illusion that the virtual object is part of the reality acquiring attributes that only real objects have, such as size, position, lighting and viewing angle.

6 Results

In order to determine if the application can be considered as a didactic tool, we applied usability testing. Those tests were performed at our university UsaLab (usability laboratory) to evaluate the application and to verify its ease of use. Also, we made another tests to measure the degree to which the developed application helps to strength the kids knowledge. A first test consisted in a questionnaire to determine the impact in the knowledge learned by students. In this case study the topic was: the bones of the human skeleton. We elaborated two questionnaires, one applied before and the second after the usability tests. These tests were planned with the objective to be applied to one person or a team. For the individual test we made an album which has marks or patterns, the smart phone displays a bone of human skeleton related to the mark; for team tests we made cubes with the same patterns (used in the individual test) printed only in one face (see Figure 10).

Fig. 11. First test using AR (Individual test).

Five children participated in the usability testing, two boys (A1 and A2) and three girls (A3, A4 and A5). The first activity consisted of answering a questionnaire to determine the level of knowledge of each student, about the bones of human body. In the first individual test, each student could appreciate the virtual image generated by the application (see Figure 11). We used two smart phones, Motorola Dext and Motoroi. Students showed an expression of surprise when they saw the virtual image. In general, for the children, the first test was fast and easy. Statistics were generated to measure efficiency of the use of the application according to the childrens behavior. A5 was notably the student that spent the longest time to detect the marks with 3min 60s. A1 was the fastest to perform the tasks in 1min. 3D virtual images showed were interesting for all of them, as an example A4 said: Ohhh .... It looks like in the cinema.

For the second test we organized three teams: T1 (A1, A2), T2 (A4, A5) and T3 (A3). A task was assigned for each team, consisting of building the human skeleton using the cubes. Each team created a different structure with the cubes. T1 built the skeleton as shown in the Figure 9.

The test was very interesting for the children, so they could work together, talking among themselves and discussing to decide the best way for assembling the skeleton [16]. When they commented about the activities, they said: We liked to work with the cubes for building the human skeleton.

After finishing the second test, students wrote a new list containing the names of the bones. Each child wrote more names than in the first questionnaire. The first time, the most students wrote only the name of the ribs, but when the same questionnaire was answered after the tests they wrote more correct names (at least five from six). Finally, the students evaluated the application with a score from 1 to 10, the degree of satisfaction reached was 96%.

7 Conclusion

We conclude that smart phones are an appropriate platform for the development of applications that seek to strengthen the teaching-learning process. Trends indicate that with the increasing sales and popularity of these devices, it can be expected to become a common element of multimedia classrooms in the near future.

Usability tests applied to basic school students, enforce the evidence that our application contributes to consolidate knowledge, providing a more enjoyable experience for them. The concepts taught in classroom were presented in an innovative and visual approach (using AR). Also, we observed that the application allows work in a collaborative way, because in order to resolve some tests, they organized themselves to discuss and finally found a solution.

Technology can help us to learn, as long as the application is well designed and clearly focused on the educational objectives to achieve. It is worth pointing out, that AR is not intended to replace a physical model that exists already; rather, it represents another option in which we can visualize abstract concepts or simply we can increase access to knowledge. This work confirm the usefulness of AR as a tool for strengthen teaching-learning process in our study case.

In the future, we will develop an application to present interactive information for museum artifacts, using mobile devices and AR, so we expect they become more attractive to general public. Also, we expected to develop collaborative AR applications for different basic grades and subjects to provide support to the teaching-learning process, reinforcing the constructivist approach for education.

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