

# A new challenge in the Electronics teaching/learning process for the Industrial Design Engineering Bachelor

An interactive educational tutorial

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**Abstract**—The adaptation of new curricula to the European Higher Education Area implies a radical change in the teaching/learning process: it is necessary to get students more involved as well as to promote their independence and active participation. The fast-growing technological development, the increasing use of Information and Communication Technologies (ICT) and the advent of e-learning technologies make possible the achievement of this change. It is described a powerful interactive electronics educational tool, which can be embedded in a web page in order to simplify its use by the university students. The results obtained by means of a test demonstrate the benefits of the use of this tutorial and the increase in the motivation students.

**Keywords**—European Higher Education Area; interactivity; Electronics; teaching/learning process; educational innovation

## I. INTRODUCTION

“The European process has very recently moved some extremely important steps ahead. Relevant as they are, they should not make one forget that Europe is not only that of the Euro, of the banks and the economy: it must be a Europe of knowledge as well. We must strengthen and build upon the intellectual, cultural, social and technical dimensions of our continent. These have to a large extent been shaped by its universities, which continue to play a pivotal role for their development”. [1]

Therefore, education is one of the most important foundations for supporting social development in a country. In the last decades, researchers have been refining both concepts and techniques and developing new tools to support the improvement of educational processes [2]. The traditional form of teaching in the classroom can be complemented by the use of interactive systems based on computers. These systems can provide a high-quality learning environment that improves student learning and, consequently, the educator’s productivity [3].

The evolution of computers associated with the rapid emergence of internet and its associated tools has provided educators with a powerful and effective mechanism for information delivery. This environment can easily incorporate

the latest hypermedia technologies (hypertexts, interactive simulations, videos/sounds, databases, remote-controlled instruments) to create and to manage educational courses, virtual laboratories, and virtual classrooms [4] [5]. The main advantages of educational systems based on internet environments are that they are independent of time and location, have a simple and familiar web browser-based interface, and offer the possibility of simultaneous attendance [4] [6].

With the advent of e-learning technologies, the accessibility of training, teaching, and learning has drastically increased. E-learning is worldwide emerging as the new paradigm of modern education [7].

Thus, this project was born with the aim of creating an interactive tutorial for the learning and teaching of Fundamentals of Electronics subject of the Industrial Design Engineering (IDI) Bachelor. The motivation behind this work includes the fast-growing technological development, the increasing use of Information and Communication Technologies (ICT), and the teaching philosophy and methodology within the European Higher Education Area (EHEA) [7]. All these factors turn the developed virtual educational tutorial into a powerful tool for information diffusion among educators (lecturers) and students.

The paper is structured as follows. In Section 2, we explain the necessity and benefits of the use of e-learning. Section 3 presents the features of the implemented tutorial. A description in detail is drawn in section 4. Finally, section 5 shows the survey results and the main conclusions of this project.

## II. ICF AND E-LEARNING

Information and Communication Technology (ICT) is progressively including greater spaces in human beings’ life, and education experiences its effect. E-learning is the use of telecommunication technology to deliver information for education and training and can be considered as an ICT innovation for many students [8].

The use of ICT in Higher Education can be considered as a requisite for adaptation to the EHEA. The new teaching

methodologies aimed at more effective and appropriate learning for professional practice involve the use of audiovisual, computer and multimedia tools on the part of lecturers.

The objective is not only to modernize higher education by introducing new and sophisticated teaching resources, but to assess the didactic possibilities of these resources in attaining the objectives sought. Pedagogical reflection about ICT should focus on how these resources can benefit university students, what they represent in the curriculum, and what they learn (competencies, attitudes, etc.) [9]. The most important thing in the use of ICT is the pedagogical method in which they are included. Thus, the knowledge, perceptions and attitudes that lecturers have in relation to digital resources is a determinant factor in their use in the educational process.

E-learning is the use of telecommunication technology to deliver information for education and training and can be considered as an ICT innovation for many students. Innovation is the situational new development and introduction of knowledge-derived tools, artifacts, and devices by which people extend and interact with their environment [8]. Colleges, universities and private training companies are converting more and more courses online. With a personal computer (PC) connected to internet, e-learning allows students to attend courses anywhere at any time. Before the telecommunication technologies became easily accessible, distance learning was delivered using mail correspondence. For interactivity, learners would have to mail back the assignments to receive feedback from the instructor or go to the tutoring center for face-to-face interaction experience. But, nowadays, e-learning has grown into a revolutionary way of learning due to the rapid development of information and communication technologies; and e-learning (or web-based learning) has made distance learning highly interactive. Students may obtain an intimate learning experience without attending a brick-and-mortar facility. Many of the prior research on e-learning are concerned with learning effectiveness and performance. Therefore, e-learning is emerging as the paradigm of modern education.

Therefore, the traditional form of teaching in classroom can be complemented by the use of interactive systems based on computers. The use of these systems has significantly improved student learning and effectiveness, and teacher's educational work. The e-learning technologies [2] employed both inside and outside the classroom are increasingly influencing the nature of teaching/learning process. Web-based learning technologies are enabling powerful possibilities for learning activities outside the classroom, both in preparation for in-class activities and in following them up [3]. Of particular importance among these possibilities is the opportunity to address learners and individuals, assessing their strengths and weaknesses and adapting learning activities in response [10].

In the particular issue of Fundamentals of Electronics, the lecturers of this subject found that students have difficulties to understand each operation of the electronic circuits (both analog and digital), mainly due to their different performance depending on configuration and the load specified. Usually, it is very difficult to illustrate these concepts in a traditional classroom using static slides and blackboard [11] [12]. In this work, the authors have developed an interactive educational tool

for the teaching and learning of Fundamentals of Electronics, continuing their work and research in the Higher Engineering Education [13] [14]. The resultant resource can be used as on-line teaching tool, taking the advantages of the potential of Internet and multimedia tools for educational purposes, such as interactivity, dynamism, accessibility any place or any time.

The benefits of this educational resource for Fundamentals of Electronics are: it combines all the basic circuits needed for a Fundamentals of Electronics course; the educational tool is an open access web; it allows students to interact with the tool and organize their learning process; and finally, it is very useful for any student of this discipline as it covers all the basic aspects of Fundamentals of Electronics (both theory and laboratory).

### III. INTERACTIVE ELECTRONICS TUTORIAL: OBJECTIVES AND FEATURES

Thanks to this tutorial (based on a web page structure (HTML format)), a new and significant innovation is introduced in the subject. Until now, the lectures explain the subject syllabus by means of static slides and blackboard. New technologies provide lecturers with many interesting tools that improve the teaching-learning process [15]. The usefulness of these tools makes important for teachers to have more information about the advantages and possibilities of using technology in the classroom [16], as well as about the results derived from their application. Therefore, with this project, these explications can be performed with animations of the tutorial interactive films. These animations provide interactive explanations of the subject theory concepts, the problem solution, the assembly of the electronics circuits and systems and, step by step, the simulation of these circuits through the PSpice program. The lectures have an important range of possibilities in order to capture the interest of the university students.

The pedagogical aim of this project is to help the lectures in their explanations and to implement a useful tool that makes possible the sharing use in a virtual space, like internet, of several multimedia computing applications for the study and understanding of the Industrial Design Engineering Bachelor students. Furthermore, this tutorial achieves an increase of the student self-learning, since they can use the tutorial as a previous activity to the classroom explanations, and even after the classes. In any case, the tutorial causes a self-learning effort; fosters the knowledge construction in the students; holds the students responsible for their self-learning; and, finally, makes possible that the students had control of the contents and activities. This tutorial is available in internet and in CD format, to distribute among all the students.

The solution of the typical problems provides, step by step, the identification of the theory knowledge; and some simulations of the same problem involves that the students become awareness of the difference between theory and practice. The students must be capable of noticing of the agreement between the theory calculations and the simulation ones.

#### IV. INTERACTIVE ELECTRONICS TUTORIAL: CONTENTS AND STRUCTURE

The structure of the educational tutorial is like the Fundamentals of Electronics subject that the lecturers explain. The different lessons are divided into several scenes with the theory and practice. The themes of each subject are increasing their complexity, as in the development of the university lessons.

It is possible enter to the different lessons by means of these buttons:

- Introduction: it consists of a presentation video, which performs an animated summary of the Fundamentals of Electronics subject. When this video finishes, the main menu appears in the interactive tutorial and we can choose to study any of the lesson subject (Fig. 1 and Fig. 2).
- Analog Electronics: this is the first important lesson included in the educational tool and it contains several explanations about the world of the Analog Electronics: devices (diodes, transistors, inductance, etc.) and the typical circuits with their applications (RC circuits, operation amplifiers, etc.) (Fig. 3 and Fig. 4).
- Digital Electronics: this is the second important lesson included in the interactive resource. This lesson consists of the basis of the digital electronics (binary algebra, logic gates, combinational systems, sequential systems, etc.) and the analysis and development of the timetable of the digital circuit performance (Fig. 5 and Fig. 6).

Each lesson is programmed in a different scene that can be chosen in the main menu. The animations enclose several buttons to move through the interactive tutorial (stop, play, go to the end, go to the start, go to the main menu, .etc.). All the videos include an explanation of the animations.

This tutorial has been implemented thanks to the use of these computing applications:

- Macromedia Flash MX Professional: this program [17] has been used to design the web page structure. The different scenes of the tutorial include animations, videos, images, text, examples, etc, corresponding to the each subject syllabus.
- Swfafla Freeware: with the use of this program [18] it is possible to convert files with .swf format to files with .fla format. This .fla files are editable and they can be modify in order to achieve the unification in the format of the several subjects.
- Notepad: it is a text edition program. The trial web page, that includes the Flash tutorial, and the evaluation test have been developed with this notepad.

Finally, some examples of scenes are drawn and each scene corresponds to each subject of the tutorial. Moreover, in the next figures, the wide range of possibilities of the tool is demonstrated (video, text, circuit simulation, scheme, animation, etc.).

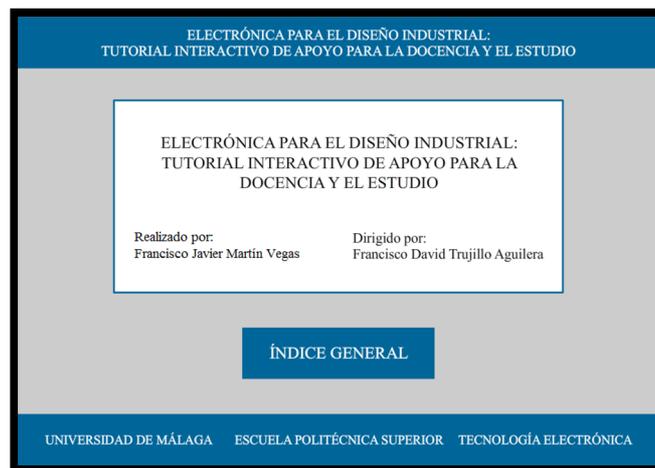


Fig.1. Start scene



Fig.2. Main menu scene

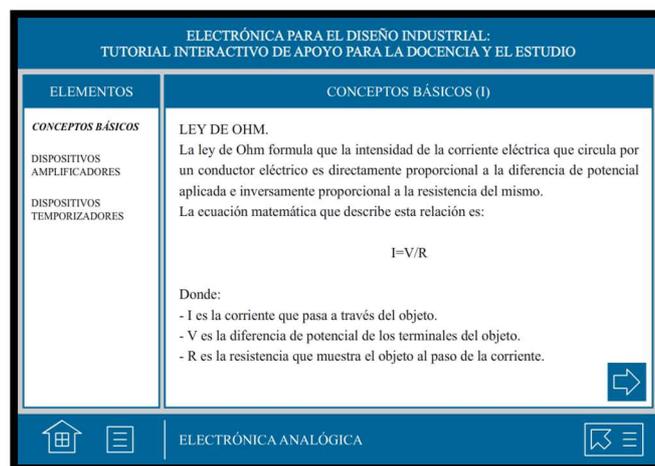


Fig.3. Example of Analog Electronics scene (theory)

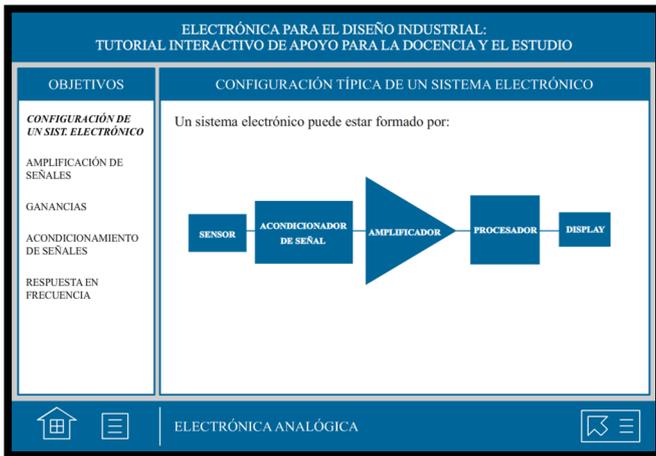


Fig.4. Example of Analog Electronics scene (practice)

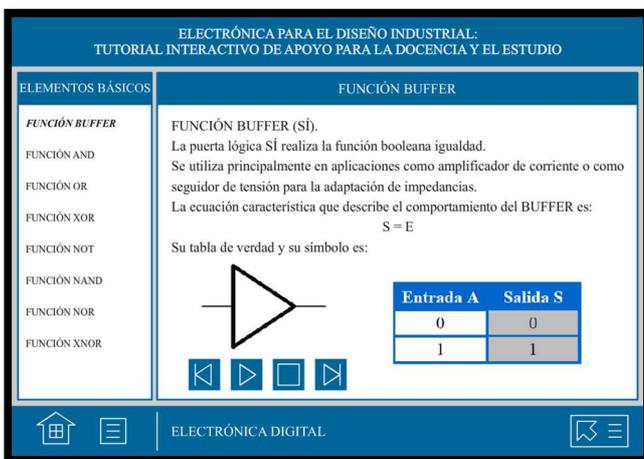


Fig.5. Example of Digital Electronics scene (theory)

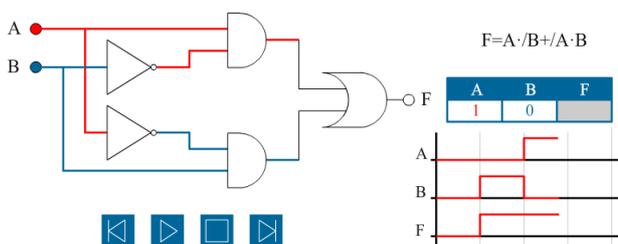


Fig.6. Example of Digital Electronics scene (practice)

## V. CONCLUSIONS AND FORTHCOMING WORKS

Finally, to evaluate this interactive tool, a survey has been developed and analyze among the students and the lecturers that have used the implemented tool. It is considered very interesting to have a feedback and to know the opinion of the tutorial user to improve the developed educational electronics tool. According to these results, the students are satisfied with the use of these educational innovations so that they improve their learning and the lecturers' productivity. In addition, the

interactive tutorial is well structured and it is easy to find the concepts of the subject.

Some important conclusions can be drawn about the results of the academic marks of the students from the beginning of the experience to the last course:

- Reduction of the number of repeat students (third registrations or more)
- Decrease of the percentage of non-taken students to the final exam (below the 20% of the number of registered students)
- Reduction of the number of failed students in Fundamental of Electronics subject
- High percentage of passed students that consider the experience as innovative and original, with important implications in the teaching/learning process, and with a very good valuation of the hard extra work of the lecturer (94%)
- Mean valuation of the subject (up to 5 points): 4.44 points

According to these results, the university students are satisfied with the use of these educational innovations so that they improve their learning and the lecturers' productivity. Also, the interactive tutorial is well structured and it is easy to find the concepts of the subjects.

Moreover, this tutorial is not a static tool. We consider very interesting to update and to continue including new subjects so that the tutorial can be extended to all the subjects of the IDI Bachelor.

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