From students and lecturers' perspectives of new on-line web-based simulation tools as Power Electronics facilities

Launching surveys for assessment stage

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Abstract—**The forthcoming European Higher Education Area has implied an important change in the teaching/learning process: it is necessary to get students more involved as well as to promote their independence and active participation. Furthermore, Information and Communication Technology is progressively including greater spaces in human beings' life, as Economics, Arts, Engineering and Education, among others fields. Therefore, a web tool, based on a content management system, has been developed to teach the Power Electronics subject. Moreover, the use of these multimedia tools makes it possible to encourage students' independence. This developed educational software is necessary as an important resource in the students' teaching/learning process. Therefore, the importance of evaluation models increases in as much as the application of these instruments allows its effective evaluation. It offers a greater guarantee of its use in these environments from the students' point of view. An evaluation process, by means of several surveys for students and lecturers, is used in order to evaluate the quality of these multimedia interactive tools. The results demonstrate that the use of this web tool increases students' motivation significantly.**

Keywords-Teaching/learning process; European Higher Education Area; Power Electronics; Educational technologies; Evaluation and assessment

I. INTRODUCTION

Nowadays, university education has undergone a significant change towards new models that encourage the active role of students in the learning process [1] [2]. The European Higher Education Area (EHEA) means an important change in the teaching/learning process. It is necessary to involve to students and encourage their independent study and active participation more efficiently. This change has occurred at the same time as the increase in the development and use of new information technology in education: multimedia applications, simulation tools, educational platforms, among others [3] [4], based on the spreading and frequent use of Information and Communication Technology (ICT).

The traditional form of teaching in the classroom can be complemented by the use of interactive systems based on computers. The use of these systems has meaningfully improved students' learning and motivation [5] and teachers' educational work [6].

Learning technologies employed both inside and outside the classroom are increasingly influencing the nature of teaching and learning. 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. It is important to highlight, among these possibilities, the opportunity to address learners and individuals, assessing their strengths and weaknesses and adapting learning activities in response [7].

The evolution of computers associated with the rapid emergence of Internet and its associated tools have 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 [8] [9]. The main advantages of educational systems based from 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 [8] [10]. 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 [11] [12].

In the particular issue of Power Electronics, teachers of this subject found that students had difficulties, for example, to understand each operation of the converters, mainly due to their different performance depending on control parameters and a specific load. Usually, it is very difficult to illustrate these concepts in a traditional classroom using static slides and a blackboard [11]. In this framework, the authors have developed a set of multimedia interactive tools for Power Electronics, gathered in an educational computer-aided platform, which can be used as an on-line teaching tool. The

platform makes use of the potential of Internet and multimedia tools for educational purposes, such as interactivity, dynamism and accessibility in any place or at any time.

The benefits of this computer-aided on-line platform for Power Electronics are:

- It combines, in a single platform, all interactive tools needed for a Power Electronics course: a complete e-book, Power Electronics multimedia animations, self-explanatory videos, Java simulations of the switched power converters, Power Electronics Laboratory tutorial, and a self-evaluation test corrected and graded automatically by the software. This is significant due to the infinite number of on-line resources and information related to Power Electronics on the web that could confuse and overwhelm students.

- It is an open access platform, that is, it is freely available on the Internet, and it can be used by any student or lecturers without charge, registration or password

- It allows students to interact with the tool and organize their learning process.

- It is very useful for any student of this discipline as it covers all the basic aspects of Power Electronics, with an extensive content.

Therefore, thanks to this computer-aided platform, a new and significant innovation is introduced in the study of Power Electronics, in order to improve the level of teaching and encourage self-learning. The main objective of this platform is to help with:

- The learning process of Power Electronics students, thanks to the use of videos, interactive circuit simulations and tests that show, the performance of a wide set of power converter topologies clearly.

- The teaching process of Power Electronics lecturers, achieving more dynamism in the classroom with more interaction and with a more active role of the students.

The use of this tool during the last academic years has significantly improved understanding of the subject of Power Electronics, in turn encouraging active student participation in their own learning process. So, with this project, the explanations of the Power Electronics subject could be performed with animations and videos. And the lecturers would have an important range of possibilities in order to capture the interest of university students.

II. EVALUATION OF EDUCATIONAL SOFTWARE

There are many advantages, described in literature, about the use of educational software [13] [14]. However, the correct use of this software tool needs a careful and accurate implementation so as to guarantee a product of quality in keeping with the specified requirements.

Nevertheless, the evaluation of educational software represents an important task so as to allow and offer a greater guarantee of its correct use in educational environments. This evaluation has been widely analyzed and studied [15] [16], providing several evaluation measures in technical and educational fields. What has been analyzed in [16], where versatile and flexible quantitative methods of evaluation are used, is very important in the pedagogical field. From this pedagogical point of view, several software conditions must be considered regarding student's features (age, educational level), teaching (objectives, motivation, feedback, used methodology) or content (types, strategies). From the technical point of view, several conditions are studied: its usefulness (the ability to use the resource, access to the program, installation, operation, navigation), as well as the interface characteristics (design of screens, disposition of menus, icons, images, color, graphics, animations).

Given the importance of software, it is necessary to evaluate some software products and related processes in a systematic way. Various criteria must be analyzed and assessed to reach the final decision. Assessment of teaching/learning software consists of two different evaluations: formative and summative.

Formative methods of evaluation are used when a project outline has been decided and work has begun on the design and development of the various parts. It can be deliberate and it can consist of a series of methods to determine whether the project can work as planned or if it can be ad hoc. Therefore, it mainly consists of obtaining the opinions of passers-by over the visual effectiveness of a series of screens [17].

In comparison, summative evaluations can be much wider in scope. They occur when the finished product is examined and can benefit from hindsight. These summative methods can be defined as the collection, analysis and interpretation of information about any aspect of a program of education and training, as part of a recognized process of judging its effectiveness, its efficiency and any other outcomes it may have [18] [19]. Due to the characteristics of the implemented educational software for Power Electronics, the achieved evaluation method is the summative evaluation, with a set of questionnaires that are explained in the next section.

III. WEB-BASED TOOL DESCRIPTION

The developed tool is intended to support the study of Power Electronics in a special way that aims at undergraduate engineering students. The computer-aided educational package, based on a content management system (CMS) [20], has been developed in a Windows environment and it is embedded in a www-html page.

The tool is divided into three modules:

- Module I: TUTORIAL. Analysis of the switched power converter performance.

- Module II: SIMULATION. Simulation of several power converter topologies.

- Module III: SELF-EVALUATION. Self-evaluation test corrected and graded automatically.

Each of these three modules corresponds to the natural process of study of the subject:

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2

- Step I: In-depth knowledge of operation of the converters and a display of the most significant waveforms with a certain control and a certain load.

- Step II: Simulation of the aforementioned analyzed converters with different control and loading conditions.

- Step III: Self-evaluation test to determine if the studied contents and concepts have been assimilated.

From the main page of the web-based tool it is possible to access the three modules, which are explained now:

A. Module I: Tutorial

In this module, the performance principles of switched power converters are explained by means of videos or animations. These videos are programmed using Adobe Flash multimedia software [21], software designed for creating web animations. Flash provides a great interactivity and it is compatible with a wide set of software. With the animations, the students can study, step by step, the analysis of Power Electronics converters. The display of this analysis is performed in two manners: analytically, showing the control parameter values; and graphically, through the final waveforms.

A total of 24 videos (see Fig. 1) for different topologies of switched power converters are implemented in this web-based tool.
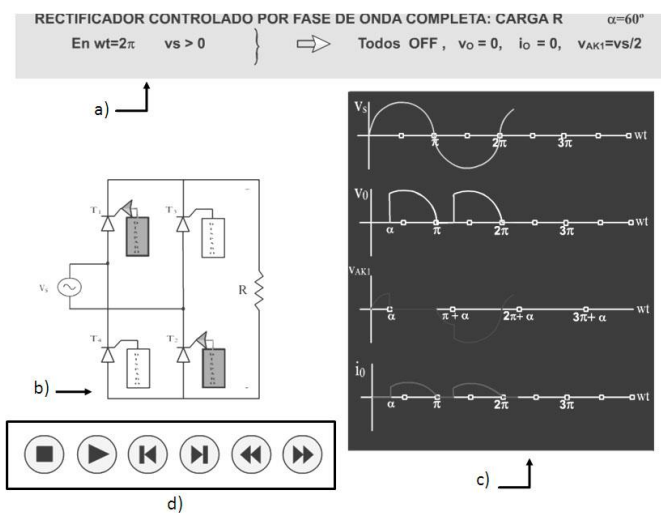

Fig. 1   Power converter video: a) Heading, b) Circuit, c) Waveforms, d) Control buttons

Thanks to these several videos, the web-based tutorial is a powerful tool that can be used to study switched power converters. The animation interactivity is supported by controlling the flow of each animation with the objective to gradually get to know the performance of a particular studied conversion in detail.

B. Module II: Simulations

In this module, students can simulate switched power converters with any load and control scheme. Nowadays, there are many kinds of simulation software like PSpice, EMPT or PSIM [22] [23], with PSpice being the most widely used software to simulate the circuits of Power Electronics.

PSpice [24] [25] is fitted with physical models of semiconductors and switching devices. Physical modeling produces well-detailed results, but leads to a high calculation effort and often introduces convergence problems during transient simulation. Moreover, PSpice needs to design control and excitation circuits of power semiconductors.

At this stage, we focus on the main objective of this tutorial: to help students in the study of the performance of switched power converters. For this reason, it is necessary to simplify simulations so that students can only choose the power converter to be studied, with both control and loading parameters. So simplification is achieved by means of the use of "black boxes".
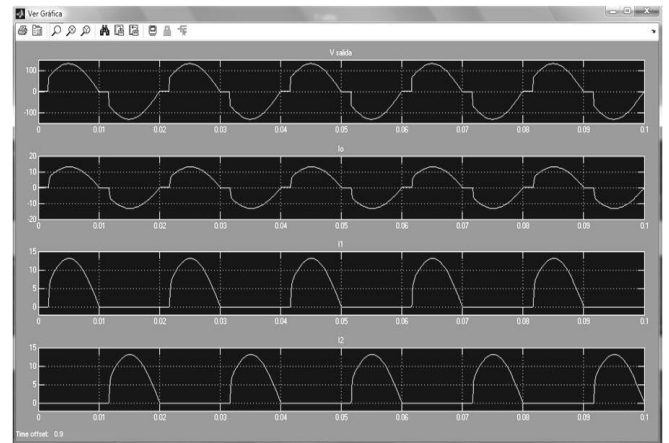

Fig. 2   Simulation results of a bidirectional single-phase ac-ac converter

After circuit simulation, it is possible to display the resulting waveforms. These simulation waveforms are drawn in Fig. 2 for the example of a bidirectional single-phase ac-ac converter showing these variables: output voltage, output current and current in the thyristors.

C. Module III: Self-evaluation

Finally, the web-based tool includes this module which contains several tests so that students can check their knowledge of both the theory and some practice problems. Three types of questions are defined:

- Fill in the blank, where responses can be strings (single and multiline), integer and floating numbers.

- True/false, depending on whether the statement is correct or incorrect.

- Multiple choices, where choices can be text or images.

The free software called Hot Potatoes [26] has been used for the implementation of these self-corrected questionnaires.

By clicking on the left button entitled "questionnaires", a sub-menu appears where students can choose a power converter for self-evaluation: ac-cc, cc-cc, cc-ac and ac-ac. The questions will be answered in sequence. When an incorrect option is selected, the next question will not be

displayed. The tool records the attempts of each question, providing the final results when the test ends.

IV. FROM THE STUDENTS AND LECTURERS' PERSPECTIVES: SURVEYS

For this new interactive tool, two surveys have been developed [27] for both students and lecturers to validate this educational resource and its correct adaptation. One survey has been designed for students (satisfaction survey) and another for lecturers, selected by an expert group of five members (validation survey).

The results of these two questionnaires are taken into account to improve the implemented tool, but only if the questionnaire results are not satisfactory, measured in terms of a scale from 1 to 5 points. In this case, once the changes have been introduced in the educational tool, the satisfaction and validation surveys are done again in order to check if the needed modifications have been performed adequately.

A. Satisfaction survey

Students validate several performance features of the tool. This questionnaire for students is composed of three fields, according to these aspects:

- Interface features: easy browsing, clear icons, disposition of menus, providing help, visible links, understandable menu, uniformity in all the screens, etc.

- Aesthetic features: well arranged information, clear texts, image quality, animation quality, colors, original design, correct letter size, motivating design, correct information volume in each screen, etc.

- Useful features: easy installation, versatile tool, instructions for use, help to understand the matter better, etc.

B. Validation survey

Besides the three fields defined below, the validation questionnaires for lecturers consist of three more fields. These fields are:

- Technical features: multimedia elements, response time, audio support, file size, image motion, document printing, easy technical requirements, etc.

- Pedagogical features: guided learning, updated contents, self-evaluation, feedback, evokes attention, redundant information, summaries, motivation, extending activities, etc.

- Skills and strategies: memorizing, comparison, analysis, creativity, interpretation, calculation, problem solving, knowledge consolidation, etc.

C. Results and analysis

All the results derived from surveys and presented in this section have been calculated by considering only students who completed the questionnaires correctly. Table I shows the number of analyzed questionnaires in this study.

TABLE I. NUMBER OF ANALYZED QUESTIONNAIRES

SURVEYS	NUMBER
Satisfaction (Students)	568
Validation (Lecturers)	40

Tables II and III present the results of the satisfaction and validation questionnaires, in terms of mean values of all the answers related to the most important aspects of each questionnaire analysis, being necessary to take into account the value of standard deviation. The responses of each questionnaire are marked from 1 (entire disagreement) to 5 (entire agreement).

TABLE II. SATISFACTION SURVEY ANALYSIS (STUDENTS)

FEATURES	MEAN VALUE	STANDARD DEVIATION
Interface	4,65	0,23
Aesthetic	4,41	0,11
Usefulness	4,37	0.20

TABLE III. VALIDATION SURVEY ANALYSIS (LECTURERS)

FEATURES	MEAN VALUE	STANDARD DEVIATION
Interface	4,25	0,36
Aesthetic	4,30	0,28
Usefulness	4,61	0,45
Technical	4,39	0,48
Pedagogical	4,58	0,10
Skills/Strategies	4,65	0,17

Table II and III demonstrate that the features of the new interactive multimedia tool are considered by students and lecturers as very adequate and suitable for the study of Power Electronics and this tool achieves the proposed objectives in terms of pedagogical aspects and promotion of important skills and strategies.

V. CONCLUSIONS AND FUTURE WORKS

The multimedia web tool is suitable complementary material for the correct teaching and learning of Power Electronics. The implementation of the platform, according to the EHEA paradigms, has achieved an important active participation among students. The developed platform has turned out to be a very intuitive and easy-to-handle tool for lecturers.

Finally, related to the survey analysis and with the idea in mind to complement the questionnaire results, it could be very interesting to perform a detailed study of the obtained students' marks in order to compare them with the previous students' scores who could not use this new educational tool.

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4

The new teaching/learning facilities, aimed at more effective and appropriate learning for professional practice, involve the use of audiovisual, computer and multimedia tools on the side of lecturers.

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