Active Learning in Power Electronics

From classroom to laboratory

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Abstract— **Changing the paradigm from lecture teaching to student learning an experience has been successfully carried out in a 3rd course in the degree: there will not be lecture sessions or lab sessions any more. Students go directly to laboratory and the sessions take place on guided experiments about each analyzed topology in the syllabus. So theoretical analysis, modeling and simulation and experimental results of power electronics topologies are carried out together by students in an active learning methodology. The facilities have been disposed in a suitable way in order to become it flexible and have got a wide set of equipment that allows to perform lecture sessions, modeling and simulation skills, web based activities or lab experiments. Moreover, a professional power systems simulation tool with limited license is offered to each student in order to support his learning process at home same as that in classroom.**

Keywords- laboratory, methodology, Power Electronics.

I. Introduction

The University of Cordoba (UCO) and its Higher Technical College (HTC) have carried out many experiences along the last seven years with the aim of adapting teaching methodologies, guides and subject programs to the European Higher Education Area (EHEA), and more specifically, to the European Credit Transfer System (ECTS).

The University of Cordoba has supported methodological innovation and improvement by means of its own Teaching Innovation and Improvement Projects Program for the last ten years [1]. This program supports financially the purchase of the needed media, materials and equipments to develop all the approved activities and provides experienced supporting personnel to help us meanwhile them are carried out.

Four years ago, one of these projects (related to a non compulsory subject on Power Electronics) included a partnership contract with Powersys Ltd. in order to obtain the needed student licenses to help the Electronic Power Systems learning [2] [3]. As a consequence, all of our students are provided with a license of PSIM® for their scholar life. This professional power systems modeling and simulation tool is one of the basis of self-learning procedures carried out in the subject referred at this paper. It is used both for explaining the power systems function and for making simulation experiments both at university facilities and at home. Even this simulation tool is able to be used in many other engineering subjects in the degree.

Once financial problems (the major nemesis on any change action) have been solved, methodologies and teaching paradigm have to be revised and updated to self learning procedures and experience based learning.

II. Active Learning Principles

Active learning focuses the responsibility of learning on learners and comprises a wide set of methodological activities and experiences. Active learning activities include, for example [3]:

- Think-pair-share activities. Learners ponder a previous lesson, later to discuss it a little group of their mates, finally to share it with the class in a formal discussion. The instructor should clarify misconceptions during this last stage. However students need a background in the subject matter to converse in a meaningful way. So, this exercise is useful in situations where learners can identify and relate what they know to others
- The learning cell gets a pair of students together to study and learn. First they read the assignment and write down questions that they have about the reading, after students alternate asking and answering questions on commonly read materials during the learning process. At the next class meeting, the teacher will merge new pairs randomly and the students will asked their own questions to each other alternatively. During this time, the teacher is going around the class from group to group giving feedback and answering questions.
- Class discussions that may be held in person or in an online environment. This environment allows for instructor guidance.
- Short written exercises are a good way to review materials, the better if they are proposed as worked-examples.
- Teaching the new contents to each other at class at a studying or working group or by means of a forum or a wikiplace. Anyway students have to be closely guided by teachers.

In our opinion, the first activities related are more formal than the last ones and requires a more structured teaching procedure. So they are more complex to be carried out. Discussions, short exercises (guided or proposed), and peer teaching are in fact more flexible and allows the teacher to adapt the learning flow to learners. Anyway, as seen in the aforementioned activities, in order to ensure efficient instructional strategy teacher guidance must be an essential part of active learning. Moreover, practice after initial learning is of vital importance in student's education. Its importance lies on the fact that students who practice discovery learning are more likely to recall information.

Many activities described before are able to be applied to experiences in a discovery learning way. Learners work in pairs during lab sessions, discuss materials while role-playing, debate, engage in case study, take part in cooperative learning, or produce short written exercises, etc. As can be seen, the whole set of activities related to active learning are used meanwhile lab experiences are carried out.

The reinforcement of learning lies on practice, discovery activities and application problems. But this last one is not always suggested specially if the matter is their first approach to a subject in the syllabus. Guided or worked-examples could then be the best choice.

III. DESCRIPTION OF THE EXPERIENCE

Some previous experiences on active learning in Electronics are almost exclusively focused on simulation [4], multimedia [5], remote labs [6] or CAD tools [7]. However, other active learning education experiences include a wide variety of activities that fit with the aforementioned principles, as in [8]. The work described in this paper matches this profile. The experience is carried out in a noncompulsory subject in the 3rd (currently the last) course in the degree of Industrial Technical Engineering, specialty in Electricity. Traditional methodology of lecture sessions and laboratory or simulation sessions has been suppressed and they have been joined in a holistic learning process [3].

A. Facilities

Students work in laboratory facilities in which lab places are distributed likewise a lecture room. The advantages of both teaching methodologies are then focuses together to improve learning. Each place in the lab is equipped with a desktop PC connected to the Internet, adequate electronic instrumentation, 3-phase 24/42/230/400 V_{rms} and DC supplies and a set of power converters adapted to educational purposes. A lab overview can be seen at Figure 1. Figure 2 shows a detailed a pair of sights of the specialized equipment in a lab place. Thus, students have means enough to a classic lecture session, to model and simulate a power system, to experiment with the lab modules, to access to the internet and the learning resources sited there or to cooperate each other.

On the other hand, teacher's place is provided by an interactive smart screen. The teacher has access to every lab place personal computer from his place. So any situation that can occur can be shown to the classmates who can give their opinion and discuss the posed problems.

Figure 1. Laboratory overview

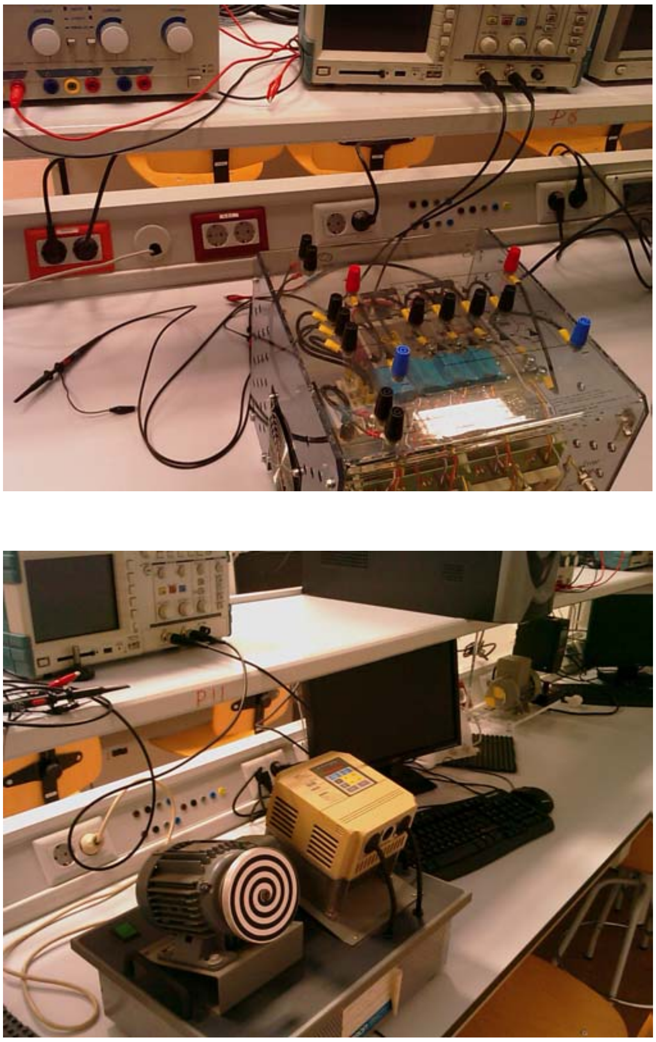

Figure 2. Lab places in detail

B. *Learning Virtual Platform*

Theoretical principles are at students' disposal by means of the e-learning platform UCOMoodle®. UCOMoodle® is an evolution of Moodle® developed at our University. Figure 3 shows the subject main page. Links to java applet simulations, data sheets of electronic devices, slides, presentations, etc. are also offered in all studied cases. So, the materials disposed give the source of knowledge background needed to active learning activities.

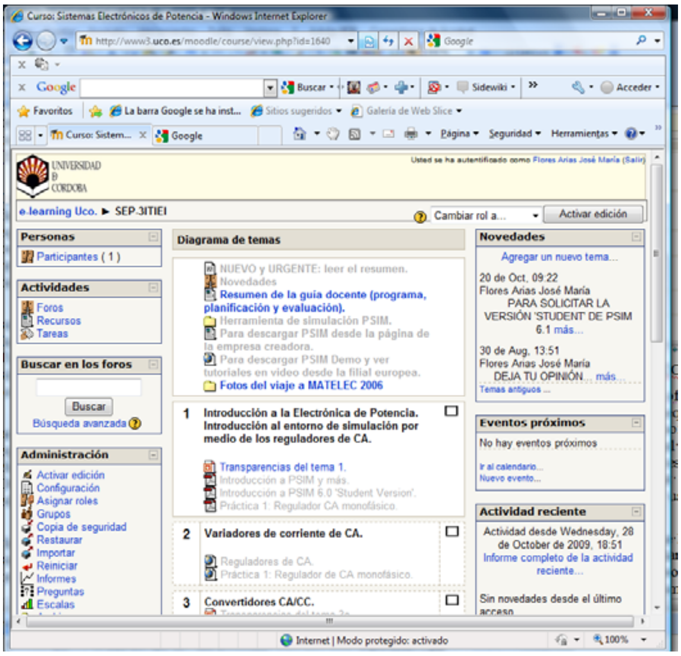

Figure 3. Subject main page at UCOMoodle

C. *Modeling and simulation tool*

Powersys Ltd. and the University of Cordoba have a partnership contract since 2005. As a consequence an unlimited number of student licenses of PSIM® software. So, All the students fro the UCO can request a student license for their scholar life due to a partnership contract between Powersys Ltd. and our University. This professional tool is able to be used for modeling and simulating power electronic systems and control, function and programmed blocks, electrical machinery, instruments and sensors and a wide variety of loads as well. It is a helpful resource both for explaining the power systems function and for making simulation experiments both at university facilities and at home.

In the presented experience, its use is restricted to analyze the behavior of the most common used power electronics topologies and to model the basis of their control modes. It also can be used in order to prepare the sessions, check the results of analyses or prepare for solving non guided cases at their convenience.

Figure 4 shows one of the analyzed topologies: A DC motor drive fed by a Buck converter with a speed control loop

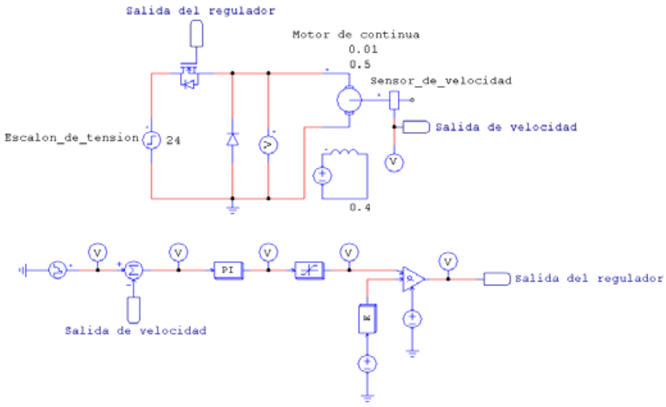

Figure 4. An example of the analyzed power systems

D. *Working at classroom and homeworking*

The class process starts with a brief introduction on a focused matter. Principles of operation of the about power topology and its basic control techniques are then explained and some worked-examples are discussed and developed for students as a class exercise or homework. Question and answers flow to each others after a think-pair-share activity or like a class discussion way. This takes place first at classroom and at a discussion forum guided by the teacher at UCOMoodle® later.

Students have to analyze and solve more complex problems after the exampled are done. They calculate the appropriate parameters of the topologies studied, model the circuits and simulate then using PSIM®. This autonomous work is done in a kind of learning cells. Another forum site at UCOMoodle is offered for sharing experiences, problems and solutions during this job.

All the collaborative activities of learning by teaching strategies at the virtual learning framework are supervised and valued by the teacher and its marks included at student studio assessment.

A set of lab sessions are done along the semester once theoretical behavior are know and operation modes have been analyzed. During its implementation a form about the experience has to be filled in and some short written exercises related with experiment functionality and lab procedures are done.

The evaluation of the acquired knowledge and competences includes a summary of the labs exercises done and a more complex analysis case than included in the syllabus. Students have to expose their work too and answer any question asked by the teacher or their classmates at the examination session.

IV. RESULTS

This methodology has been carried out in several non compulsory power electronics subjects in the syllabus by the group of teachers aforementioned at authors' field. An average of twelve students (between six and twenty students) has been attended in these subjects. Lab facilities can be employed by up to twenty four students at the same time.

Presence rates have been improved in all cases up to almost the 100% across the last four years. The success rate didn't change significantly but marks have grown for all the students.

Satisfaction surveys within our quality control system show an important approval of the adopted methodology. Unfortunately we are not authorized to show any of these quality index data.

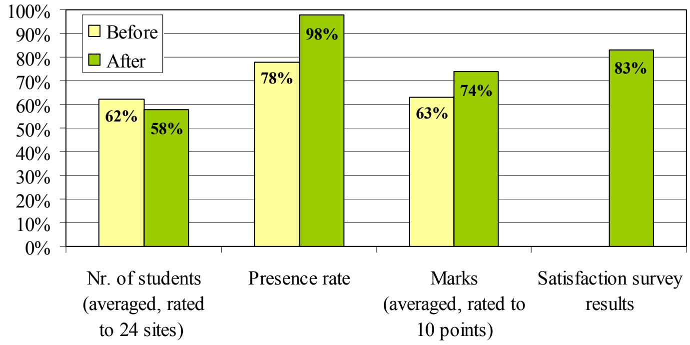

Figure 5. Comparison overall rates before and after adopting the presented methodology

V. CONCLUSSIONS

An active learning methodology has been planned and successfully carried out, including a wide set of proposed activities. Lecture sessions, simulation exercises and lab experiments are able to be given at the same place and at the same time without any break in continuity. Students have welcomed the experience for the last five courses and their marks have significantly improved. Absenteeism is negligible.

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REFERENCES

[1] On line: http://www.uco.es/organizacion/calidad/actividades_propias/pimcd/pimcd.htm

[2] J.M. Flores-Arias *et al*. "05NP077: Entorno de modelado y simulación en electrónica de potencia y tecnología electrónica". UCO Teaching Innovation and Improvement Projects Program for course 2004-05. 2004. Internal document.

[3] J.M. Flores-Arias, E. Herruzo, M. Linan. "Dos experiencias contrarias de implantación de créditos europeos en asignaturas tecnológicas dentro del plan piloto de la EPS/UCO. Adecuación y ruptura.". 1st Conference on ECTS pilot experiences at Andalusian Universities, Cadiz (Spain). Sep. 2006. Document 032, page(s) 1-10.

[4] F. Saharil, A.M. Hasbi, H. Hussin. "Educational Java applets for MOS capacitor" IEEE International Conference on Semiconductor Electronics, ICSE 2004.. 7-9 Dec. 2004 Page(s):4 pp. Digital Object Identifier 10.1109/SMELEC.2004.1620965.

[5] K. Li *et al*. "Semantic organization to enhance active learning based on distributed multimedia educational resources" IEEE International Symposium on Consumer Electronics, 2004 Sept. 1-3, 2004 Page(s): 436 – 441.

[6] M. Huba, M. Simunek. "Modular approach to teaching PID control" IEEE Transactions on Industrial Electronics, Volume 54, Issue 6, Dec. 2007 Page(s): 3112–3121. Digital Object Identifier 10.1109/TIE.2007.907024.

[7] J.C. Thomassian, A. Desai. "Interactive learning modules for innovative pedagogy in circuits and electronics" 38th Annual Frontiers in Education Conference, FIE 2008. 22-25 Oct. 2008 Page(s): F2A-7-F2A-10. Digital Object Identifier 10.1109/FIE.2008.4720462.

[8] W. Guoping. "Work in progress - Preview, exercise, teaching and learning in digital electronics education" 38th Annual Frontiers in Education Conference, FIE 2008. 22-25 Oct. 2008 Page(s): T2C-1-T2C-2. Digital Object Identifier 10.1109/FIE.2008.4720251.

[9] A. Moreno-Munoz, M. Linan, J.J. Luna, J.M. Flores-Arias. "E-Learning in Power Electronics Converters Area". (2005). IADAT –e 2004 International Conference on Education, Bilbao (Spain). Jul. 2004. Page(s) 1-7.

[10] Starrett, S.K., Morcos, M.M. "Development of a power learning environment" 29th Annual Frontiers in Education Conference, FIE '99. Volume 1, 10-13 Nov. 1999 Page(s):11B6/1 - 11B6/6. Digital Object Identifier 10.1109/FIE.1999.839237