Internet based complementary learning and assessment

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"I hear and I forget. I see and I remember. I do and I understand": a Chinese proverb even old in time however very actual. Following this idea, teachers from a Portuguese university, from different engineering knowledge areas, came together leading an experience of application of new methodologies in several engineering graduations courses: b-learning solution in the Industrial Electronics undergraduation course for Numerical Methods (NM) (3th year), Automation (A) and Process Control (PC) (4th year) subjects. Our goal was not only to improve student's motivation but also to facilitate student individual study. The students accepted this methodology with motivation and became more responsible in their learning process. In the last year of engineering graduation, some multidisciplinary final projects works were proposed. The advantage of these multidisciplinary projects was to enclose several areas covered during the undergraduate course, in particular NM, A and PC (subject that at a first view have apparently no relationship). These projects consisted on: (1) monitoring, control and simulation of a mini-bioreactor (covering the Process Control, Numerical Methods and also Programming areas of knowledge); (2) development of learning objects through the construction of simulators and contents in Web environment based on real mechanical systems (level measurement and control of closed loop system and strain material measurements). ICTs (Information and Communication Technologies) were also used for the oral assessment of two of these final project works. These works must be oral presented and discussed with an assessment board (supervisors and external elements). The external elements can be from others Universities. For an important time and cost saving, Skype® conference functionality was used, enabling free comment exchange between exam board members. The on going work is focused on the design and implementation of remote laboratories to run in parallel with the existent virtual environment.

Keywords b-learning; ICTs; virtual and remote labs.

1. Introduction

The Bologna declaration brought significant adjustments in the high level education in Portugal as well as in several European countries. The learning process is centralized in the student. This implies not only a precise definition of objectives and capabilities to be acquired, but also strategies and teaching methodologies reformulation. The student should play the principal role in the learning/teaching process; he/she should be engaged in doing something besides listening to a lecturer and taking notes. Different and capable learning tools must be available for an autonomous study, helping the student to reach with success his/her university degree. Nowadays, the use of the Internet as a vehicle of knowledge transmission becomes more demanding [1]. The availability of the wireless in the university campus can help this increase, in particular from student's point of view. Following this trend, for a higher rigorousness in the information spread and display, for a higher incentive and support in higher failure study areas, this topic comes into sight. The student can have an immediate feedback, allowing him/her to work at his own pace, being non-judgemental, and providing the opportunity to practice when and where he pleases.

This web-assisted learning tool is regarded as a complementary learning. It consists of coupling the class teaching with the free teaching through the Internet, with animated case studies and interactive means, where students are active pieces in the learning process. It is an active learning as instructional activities engage students in doing something besides listening to a lecturer and taking notes [2]. Cognitive theory states that knowledge learned and applied in a realistic problem solving context is expected to

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be remembered and used properly when needed later. In fact, these problem-based learning/teaching strategies, case methods and simulations, are useful tools for an effective teaching since students must become active participants rather than passive observers. Students must make decisions, solve problems and analyse the results achieved [3].

With the proposed research we implement and test different teaching/learning strategies during graduation courses (on 3rd and 4th years) and multi-disciplinary projects in the final year; also remote assessment was tested in final projects as a convenient and successful tool in students' evaluation.

2. Methodologies applied

3.1 In the learning process

The teachers involved in this project are aware of and concerned with the decline in students' mathematical knowledge in undergraduate engineering courses, and also with their motivation on this matter.

The case studies presented, describe the experiences gained from three subjects on the last three years of the Industrial Electronics Engineering course at the Engineering School of the University of Minho, Portugal. Three core subjects, Numerical Methods (3rd year), Automation and Process Control (4th year), were chosen due to their different pedagogical material and to the range of tools employed, different solutions and resources used in the implementation of a blended learning strategy. For a more detailed reading see [4]. All the three subjects have a website used as a support to the traditional lectures. Text formats like PDF/DOC (for downloading the complete theoretical support and suggested exercises), web-based search devices and hyperlinks to others web pages related to the subjects and communications technologies (e-mail and forum for asynchronous communication and chats for synchronous communication) were also used. The student, when he/she would like, can test his/her knowledge on a particular subject by solving several true or false sets of available questions. At the end, the student can get the test mark by pressing the submit button.

Knowing that interactivity with the student is essential not only for a clear understanding of the subject in study but also to make the learning process a pleasant activity, a list of animated and controlled examples concerning practical and real-world examples were developed. Sound was included in order to make the examples more real. Figure 1 illustrates one of the several available examples related to Automation subject. The student can visualize and analyse all the automated process with the correspondent Grafcet.

Different real-world systems were considered for Process Control subject: electrical, hydraulic, thermal and mechanical. They can run in open and closed loop mode and process and control parameters can be changed while running the simulation. Figure 2 illustrates one of the practical simulations of first order system, the electric case study, in closed loop control. In Process Control, the practical examples used are described by a set of differential equations. The simulations run in time domain using integration methods for solving ordinary differential equations. MatLab® (Math Works Inc.) based programs can be downloaded from the website for testing. Thus, the student can put into practice the knowledge previously acquired in the Numerical Methods subject. The animated applications developed can also help in the interpretation of the behaviour of numerical methods in solving specific engineering problems.

3.2 In final year multidisciplinary projects

The graduation courses at Minho University include one semester-long seminar of professional training. This can take place within the University or in an external institution. We will describe two different experiences: one for the Industrial Electronics Engineering and the other for the Mathematics and Computational Sciences undergraduate courses. These proposed projects were relevant not only for its multidisciplinary work, including areas focused during the course (Programming, Process Control and Numeri-

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cal Methods), as well as an opportunity to the student, from a theoretical science area, to deal with engineering science matters.

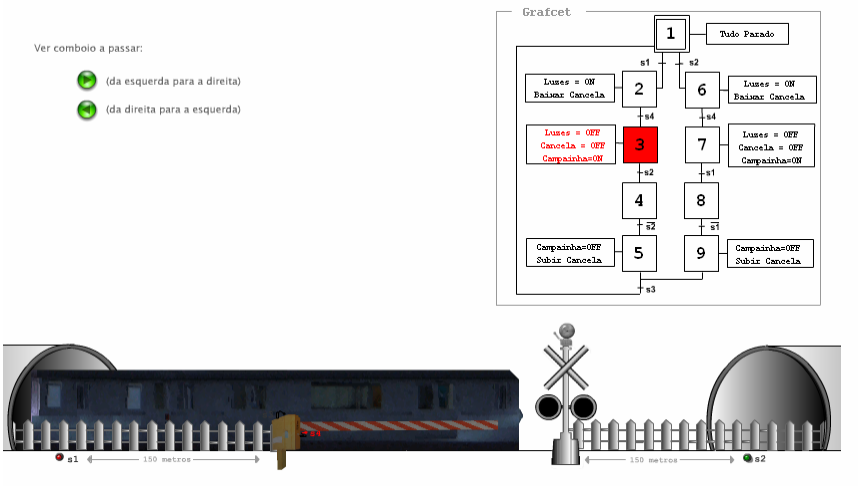

Fig. 1 Animated case study: railway train passage (in Portuguese). In the up right hand-side the correspondent Grafcet where the student can follows the automated process (the active sequence is marked in red) (http://dei-s1.dei.uminho.pt/lic/AUT/).

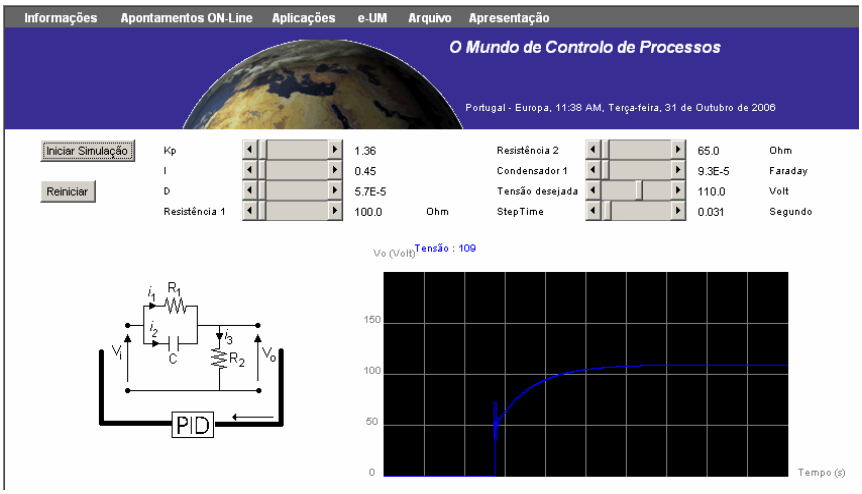

Fig. 2 Web page illustrating a practical simulation of first order system, the electric case study, in closed loop control (in Portuguese) (http://controlo-processos.dei.uminho.pt/).

The first project, BakSIM (Baker's yeast SIMulation) application, was developed for monitoring, control and simulation of a Mini-Bioreactor running in open or closed loop mode [5]. It was developed using the platform LabVIEW and the data acquisition board 6024E, both from National Instruments. The application permits several tasks: data acquisition of the most relevant system variables (biomass, ethanol, oxygen, glucose and carbon dioxide) for the real fermentation process, simulation for the virtual fermentation process and, simulation & acquisition allowing the comparison between the real and simulation final results. Some extra functionality were implemented allowing to export the resulting data of the simulations or experiences to EXCEL, as well to keep them in the data base ACCESS, facilitating the creation of reports. The simulation requires the integration of a set of non-linear differential algebraic

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equations, concerning the state variables, the mass transfer relations and the kinetics laws. The study of the effectiveness of several numerical methods can be performed. One more advantage of this project was its multidisciplinary work, enclosing several areas covered during the undergraduate engineering course, namely Programming, Process Control and Numerical Methods. In open loop mode there is no control of the ethanol concentration level, in opposition with closed loop mode where the control is possible through a PID (Proportional, Integral and Derivative) algorithm that operate on the feed flow substrate. The user can define the initial parameters and conditions for the respective simulation and can modify the kinetics parameters and yield coefficients to be considered. As the simulation runs, the user can observe the concentration profiles of all six state variables (Figure 3).

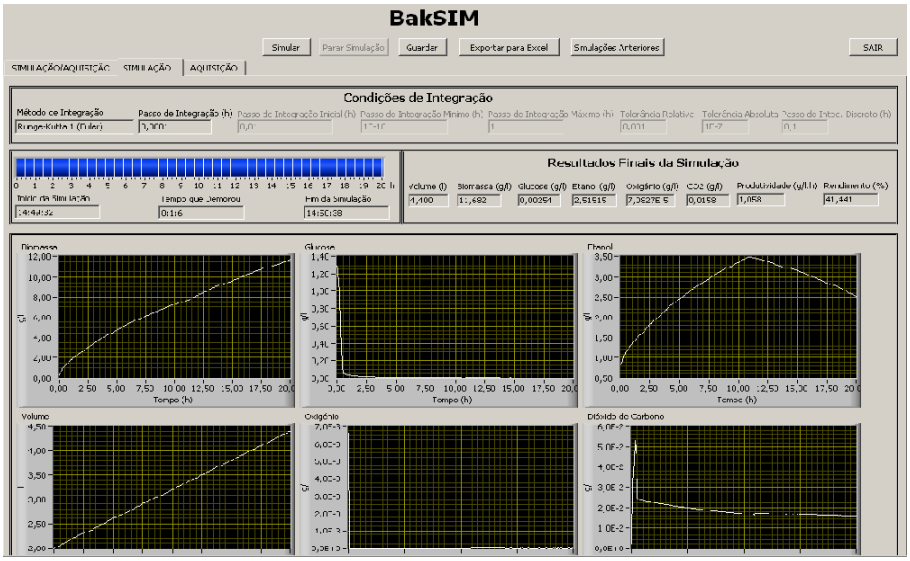

Fig. 3 Simulation interface final results under pre-defined parameters and conditions (in Portuguese).

The second project proposed consisted on the development of learning objects in a web environment for virtual components to put on evidence the characterization of mechanical properties of materials and tank-level control process (Figure 4). These systems should be a replica of the real set-up built at Faculty of Engineering of Porto University, as a Remote Laboratory component.

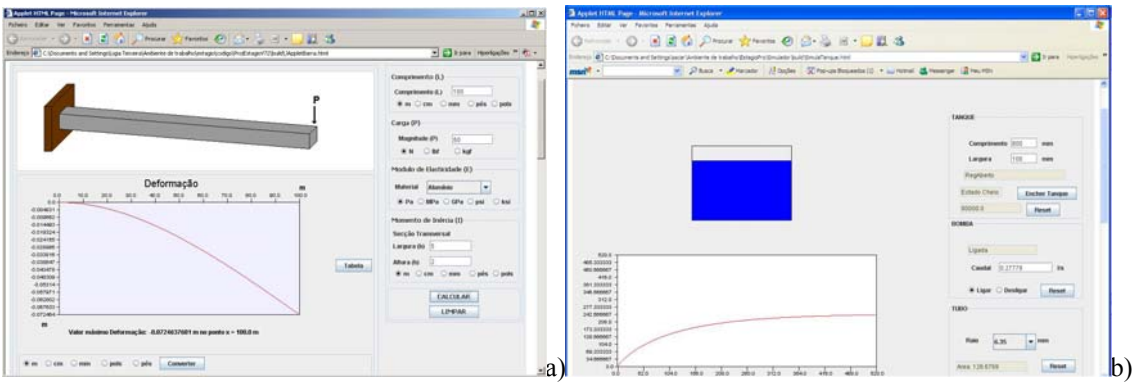

Fig. 4 Virtual laboratory: a) characterization of mechanical properties of materials; b) tank-level control process.

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3.3 In assessment final projects

The final work developed by the student during the semester must be publicly presented and discussed with an assessment board (supervisors and an external element). The exam board members from Minho and Porto Universities as well as the student agreed on using Information and Communication Technologies (ICTs) for oral assessment.

The technologies used are based on IP voice and video communications systems: The Skype® software is a free application offering the possibility of making free calls to anyone all over the world. It offers excellent sound quality and high security level with end-to-end encryption [6]. It does not need any special firewall configuration or router or any other networking gear and is available for Windows, Mac OS X, Linux and PDAs using pocket PC. The network camera captures and sends live video directly over an IP network and enables the users to view and/or manage the camera using a standard Web browser or video management software on any local or remote computer on a network, allowing authorized viewers from different locations to simultaneously access images from the same network camera. The assessment board members at Porto University were following the live presentation taking place at Minho University. Using the Skype conference functionality, the board members were interacting by exchanging written comments throughout the presentation.

4. Conclusions and Ongoing work

New teaching methodologies are being employed and tested in high level education. Students are now the nucleus of the teaching/learning process, having a more reactive and participated attitude. This situation implies, necessarily, from the teacher an active attitude in order to stimulate students in their learning process. Here, the Internet appears as a convenient tool. Employing the technical means of programming in the Internet, teachers can expose the subjects in a structural way, animated, coloured and always available for seeking.

This work presents new methodologies applied in the learning process, in final year multidisciplinary project and in the assessment. The idea is focused on b-learning solution were students are encouraged to complement classes with web simulators and guided theoretical tours. The benefits of providing such a complementary learning are also: a higher rate of students' approvals, an increase in students' engagement, an improvement on students' responsibility, a better communication between students and teachers. The final year projects engaged students in a multidisciplinary work, building the bridge between Numerical Methods and Process Control subjects. ICTs proved to be efficient in the remote assessment of final year projects. The authors also state that in addition to an important time and cost saving it also enabled, in an efficient way, free comment exchange between exam board members.

The remote access to physical devices direct connected to the internet is considered as future work, in order to give to the student a realistic perception of the real physical experiment.

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