Chapter 28

Application of new methodologies in an industrial electronics engineering course: case study

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This paper describes an experience of 'blended learning solution' in different areas of an engineering course at a Portuguese University. This arose from the current interest in innovation and the new trends in engineering education. The communication between teacher and student is becoming increasingly important in students' learning process. The Internet makes this communication possible and web tools, such as multimedia and video, makes it a practical:proposition: when the personal contact is not feasble the Internet enables contact through e-mail and web tools, as animations, motivate students to study. The solution described is a mix of traditional learning practices and e-learning, a blended approach that was implemented in the Industrial Electronics Engineering graduated course at the University of Minho. Three subjects were selected: Numerical Methods (3rd year), Automation (4th year) and Process Control (4th year). Due to the characteristics of numerical methods subject, problems are usually solved by using computers and, as this new methodology computer-based, students readily adapt and are naturally motivated. Using the knowledge acquired by this experience with numerical methods, the same methodology was applied to Automation and Process Control. Along with web tools and Internet services used for information retrieval and learning repository, some animations related to the subjects were included as well as self-evaluation tests, to allow the student to reflect on his/her learning process in a specific subject. In Process Control, a management web page functionality was included. The implementation of this solution requires a better and more precise definition of the subject objectives and contents, and subsequent assessment. While initially increasing teacher workload it also facilitates students' individual study. This new methodology has been well accepted by the students, making them more active, better motivated and more responsiblr fortheir learning process and progress.

INTRODUCTION

Education systems must promote the implementation of new methodologies not least to satisfy industrial needs. The paradigm of pedagogical organization is the teacher/discipline autonomous binomial, a passive learning methodology. With increasing student numbers, traditional, passive teaching is no longer adequate or satisfactory.

There is an urgent need for new methodologies to interacting with students that are more active and responsive. The teacher should be a catalyst in the knowledge acquisition process.

The main player in the learning process should be the student not the teacher. Shank and Cleary [1] state that "learning willing is the necessary condition to learn" and "to learn is to do". Shank and Cleary refer to the learning process as a feedback control strategy. There is a concept, we test its applicability, we verify the success and we change or reinforce the concept in order to keep as close as possible to the reference. The existence of feedback control shows the need for learning.

Nevertheless, students are not always motivated and enthusiastic present and the teacher has to actively stimulate students in the learning process. The Internet appears to be a strategic tool in the stimulation process. Using the Internet, teachers can develop programs that approach subjects in a structured, animated, coloured manner that can be permanently accessible. 'Surfing' the net is a free and friendly way of accessing a huge amount of information.

Web-assisted teaching is regarded as a complementary learning. It consists of combining class teaching with the free teaching through the Internet, with interactive animated case studies, where students are active participants in the learning process. The benefits of providing a complementary learning are: a higher level of student satisfaction, an increase in students' engagement, enhanced student responsibility and better communication between students and teachers.

Web-assisted learning complements traditional teaching has been well accepted by students. It allows them to apply previously acquired informatics knowledge and to develop new skills.

In this paper, three different experiences applied to Industrial Electronics Engineering undergraduate course are described. The core subjects Numerical Methods (NM) (3^{rd} year, 2^{nd} semester), Automation (A) (4^{th} year, 1^{st} semester) and Process Control (PC) (4^{th} year, 2^{nd} semester) were chosen due not only to their different pedagogical material but also to the range of tools employed, different solutions experienced and resources used in the implementation of blended learning.

CASE-STUDIES

The case studies presented in this paper describe the experiences gained from three subjects from the third and fourth years of the Industrial Electronics Engineering course at the Engineering School of the University of Minho, Portugal. Each subject involves around 60-80 students. Since the students theultimate users of the World Wide Web-application developed, our goal goal is to present the information in a simple and understandable way. All documents are written in Portuguese since we were dealing with Portuguese students. After evaluating the success of the initiative, the documents are to be presented in English.

Numerical Methods (NM)

The teachers involved in this project are aware of and concerned about the decline in students' mathematical knowledge in undergraduate engineering courses. NM is a topic where the use of computers is very demanding and play a very significant role: engineering numerical problems are usually solved using computers. In 2001/02, as an initial approach and following the new trends in education methodologies, web facilities were used as a support for the traditional lectures [2]. Text formats like PDF/DOC and graphics formats like JPG/BMP, web-based search devices and hyperlinks and communications technologies (e-mail and forum for asynchronous communication and chats for synchronous communication) were also used. The NM web-page, Figure 1(A), was created as a way to address the theoretical topics. It includes: a main menu, which enables the student to reach the chosen information, namely the course background information; the NM programme; some links to other Internet addressess with relevant information; some assessments and previous examinations; and the NM forum link. This last facility, permits in a quick and easy way for the teacher to note students' concerns and to address and comment on these concerns without any party being physically present. This is important for those students who are unable to attend classes. However, the e-mail proved to be the favourite way to reach the teacher.

With this new methodology, the interaction between teachers and students was stimulated and improved and, as a result of students' suggestions, the NM web page has been modified (http://www.dps.uminho.pt/pessoais/cpl/mn-leeic/index.htm). In 2004/05, a Learning Management Systems (LMS) was put in operation. This is the EASY e-Education Platform available in the University of Minho [3], Figure 1(B). EASY enables a number of different students tasks namely the on-line assessment, participation in chats and forums, FAQ, and videoconference. Online assessment was used to test students' MN knowledge and also to allow teachers to sheck students' performance.

Automation (A)

The project was conceived as a tool for the Automation subject. Interactivity with the user is essential for a clear understanding of the subject. Introducing some animations in the simulator, with practical and real-world examples, should make the learning process a pleasant enterprise. In order to achieve this goal, we select Macromedia tools [4, 5], Flash (as an animation editor) and Dreamweaver (as HTML and PHP editors). The website runs in: http://dei-s1.dei.uminho.pt/lic/AUT/index.html (Figure 2).

As frequently found in educational pages [6-8], the user may access the program, where the objectives, pre-requisites, examinations rules and timetables are defined.

The student can freely 'surf' through theoretical aspects of this Automation subject that are divided into small chapters [9]. An introduction to 'discrete event control' is described and resume of the equipment used in the control loop, such as sensors, actuators and logical controllers, is presented. The Boolean algebra concepts, concerning definition, theorems, truth tables, expression simplification, and Karnaugh maps, are also covered. If the student understands these concepts s/he should be able to design combinational controllers. The design of sequential controllers is described in detail. Their design follows the same methodology as that of combinational controllers, except for the need of using memory elements that contain the state sequence of process

automation. The outputs depend also of state sequence. The Grafcet [10] appears as an important tool in the design of sequential controllers. Their elements, basic structures, syntax and evolution rules are fully described. Some automation examples are presented to complement the study. Finally, programming languages are referred to, in particular graphical languages.

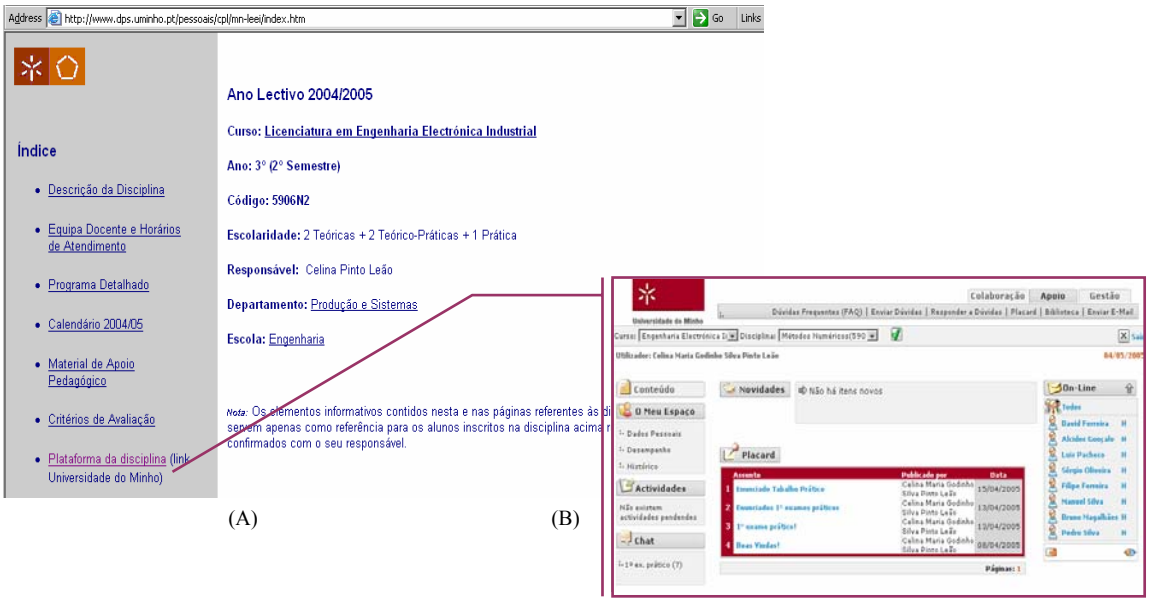

FIGURE 1
NUMERICAL METHODS 2004/05 WEB-PAGE: (A) FIRST PAGE; (B) EASY E-EDUCATIONAL PLATFORM DETAIL

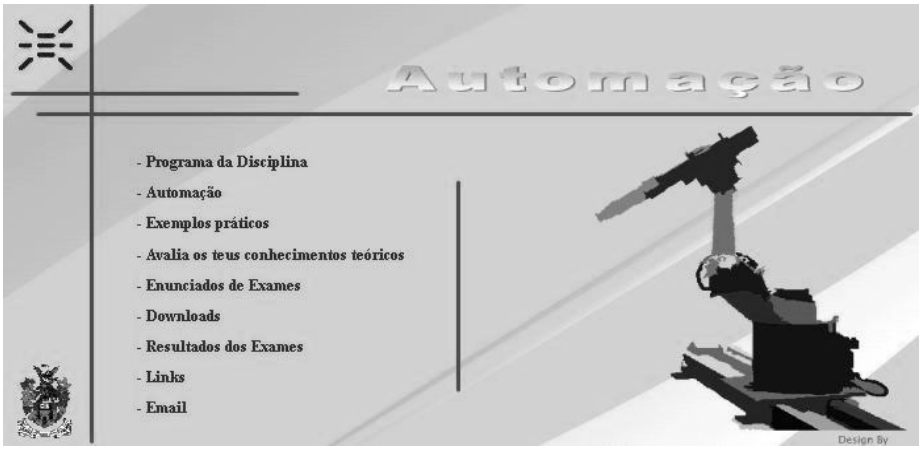

FIGURE 2
AUTOMATION FIRST WEB PAGE

Students can download the complete theoretical support as a PDF file, as well as the subject programme and suggested exercises. They may also see the examinations for the last three years and access the on-going examination marks. Some important links to other web pages related to automation processes also available. Students can directly send an email to the teacher.

In order to develop an appealing site we create a list of practical examples that are animated and controlled (like small videos, including sound). The animated case studies are developed in Flash. Generally, each file is around 75KB, which makes it possible to run the site through a 56K modem installed at student's home. Four case studies are available. In each we have the animated drawing where the user can interact with the animation by starting or modifying it. Sound is included in order to make the examples more real. In Figure 3 and 4 two examples are illustrated: selector and filling process, respectively. Simulataneously, the student has the possibility of analysing all the automated system, including sensors and actuators positioning, as well as following the automated process with the correspondent Grafcet. In the Grafcet, the active sequence is marked in red. By analysing the video and the Grafcet the student can easily make the connection between the design tools and the real-world automated process.

Finally, the student can test his/her knowledge on this automation subject by solving several tests. There are ten tests available, each with ten true or false questions. A third option is available in the case the student doesn't know the answer. At the end, the user can submit button by pressing the submit button and automatically has the test mark. The final markis determined as a percentage. These tests are based on a JavaScript that verifies which radio buttons were pressed.

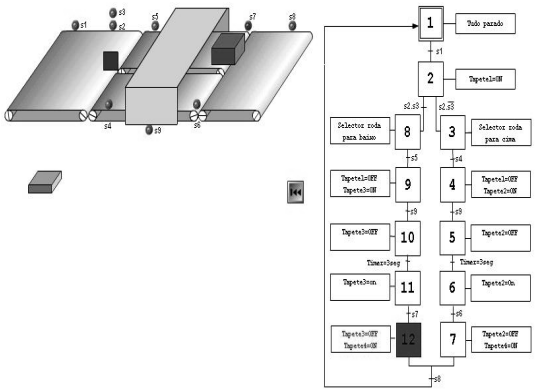

FIGURE 3
ANIMATED CASE STUDIES: SELECTOR

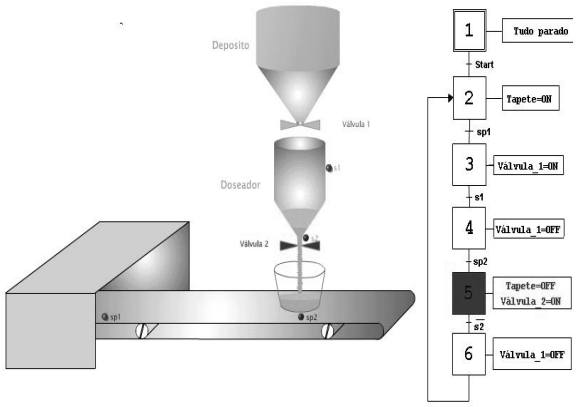

FIGURE 4
ANIMATED CASE STUDIES: FILLING PROCESS

Process Control (PC)

The project runs in http://controlo-processos.dei.uminho.pt/ (Figure 5) and supports Process Control and Digital Control topics. The web page allows, together with others common features, three main activities: (a) on-line information, where the student can 'surf' through the theoretical PC contents; (b) on-line visualization of case studies; (c) a PID toolkit, developed using MatLab, to run examples off-line by changing PID parameters.

FIGURE 5
PROCESS CONTROL MAIN WEB PAGE FOR THE INDUSTRIAL ELECTRONIC ENGINEERING OF UNIVERSITY OF MINHO

An object-oriented, robust, secure, multi-threaded programming language was used. For the web application, a Java applet was created and not a stand-alone application because the tutorial and the application must be integrated to assure the compability of

simulation with theory information background. There are mathematical tools that constitute powerful programming languages for scientific and technical computations. MatLab® (Math Works Inc., http://www.mathworks.com) is a powerful example of such simulation language. Nevertheless, in the Java Simulator, the Euler method was applied for the integration of sets of ordinary differential equations (ODE).

The student can 'surf' through theoretical support which is divided into four main chapters. The first deals with process classification (linear/nonlinear, continuous/discrete) and mathematical modelling of electrical, hydraulic, mechanic (rotational and translational) and thermal systems. The second chapter describes the control strategies and types (ON-OFF and PID), controller performance and the effects of the control actions and controller tuning. The third and four chapters present state space modelling concepts in continuous and discrete time domain, respectively. Additional information, i.e. Laplace tables and mathematical basic background, is also available. In each topic, key and remember points are present. Both indicate the need to learn a particular part and/or calling attention to a special feature. This way the student can keep track of what he needs to know and recall some mathematical tools that are needed to complete the study [11].

Solved exercises, examples and tutorials are present throughout the theoretical part of this project. The Mathworks Matlab Control toolbox is used extensively in order to give students simple examples. Different real-world systems can be run in open and closed loop mode, namely electrical, hydraulic, thermal or mechanical. Process and control parameters can be changed during simulation runs. PID classical control algorithms are implemented. The Java routines ("java.awt" library where AWT stands for Abstract Window Toolkit [12, 13]) that implement the simulation are based on an executable class, the AppletHidra.class. The executable implementation will be activated when the simulation is started. This determines when and with what parameters the simulation will run. In every case the model equation, the animation of system scheme representation, the fields to introduce the model and/or control parameters and the graphical response are presented. Figure 6 represents a practical simulation, a thermal case study, defined by a first order system, in closed loop control.

The PID toolkit, downloadable from the web page, is composed of some Matlab® functions compiled in m-files that can be called from the Matlab® prompt. With PID toolkit the student can test what was learnt or still complement the study by using simple functions. Special care was taken in providing the student with some functions that could be used intuitively to calculate the PID controller parameters. A simple approach to the PID controller was used in the *PIDcontrol* function and the *ZNval* function, giving the open loop and closed loop Ziegler-Nichols values. The different plots can be drawn in the LTIviewer, allowing the student to see system characteristics such as the settling time, the percent overshoot and the rise time. In addition, the open loop and closed loop Transfer Functions are showed in the Matlab® prompt. This function is best used to observe the different effects of the control actions to a step response.

In order to address on-time web information, a simple and easy web page management program was designed. It was not our purprose to develop an LMS (Learning Management System) with all the functionalities but as an alternative tool to be applied to the management of simple contents of complete and self contained web pages. This 'microLMS' was developed mainly in PHP (Personal Home Page Tools) [14], and the final part took us a step further from the original concept of web assisted learning to a

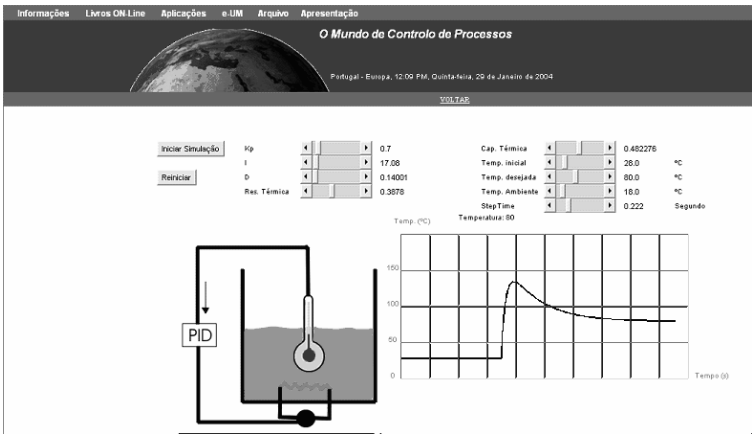

FIGURE 6
WEB PAGE ILLUSTRATING A PRACTICAL SIMULATION OF FIRST ORDER SYSTEM, THE THERMAL CASE STUDY, IN CLOSED LOOP CONTROL

first step to e-learning. The PHP code has an incorporate database that fulfilled our needs, namely in keeping and editing information to students/teacher. The database was created in MySQL [15] 'commercial off the shelf'. With the interface, teacher and students can manage their tasks by inputting individual username and password. Students must submit an application to be accepted by the teacher who has supervisor and manager roles.

The contents of the on-line theoretical support are managed through simple editing of the existing HTML files. As administrator, the teacher can introduce, change or remove documents for user download and is able to renew general information. Questions regarding theoretical aspects of Process Control can be inserted or removed from the database. These on-line questionnaires are randomly selected from the database. The administrator can also verify the frequency and number of occasions that a student has accessessed web page. Students can obtain their grades, examinations or project specifications and their marks by e-mail or consulting the page.

Summarizing, the 'microLMS' allows the teacher to manage the simpler contents of the site that may need frequent change, including:

- Files available to download;
- Students' marks;
- News and warnings;
- On-line self evaluation.

The first three are quite commonly found in educational web pages. The fourth, on-line self-evaluation, is available sice it is one the basis items of e-learning. This facility allows the student to follow their performance on-line in this subject.

CONCLUSION

Over the years, subjects have been taught in the traditional way, namely, in the classroom with the teacher transmitting knowledge while students listen passively. With advances in technology and web facilities, computer-aided (or web-aided) teaching at undergraduate

level, together with in-class teaching, is becoming an important tool for reaching and motivating students in the learning process. Moreover, it is especially important for those students who are unable to attend classes.

Concerning Numerical Methods, students use the NM-web page functionalities to access the lectures summaries, and the download and e-mail (the preferred way to access the teacher) areas. The use of the EASY e-Education platform enables students to perform electronic self-evaluation and also allows the teacher to follow the students' performance. At least 50% of the student registered used this platform. Several animated applications have been developed, particularly animations that help in the interpretation of the behaviour of numerical methods in solving specific engineering problems.

A web-assisted package for undergraduate Automation studies was developed in Macromedia Flash environment. It includes several features, in particular, the structured presentation of theoretical aspects of automation; animated examples where students can visualize the animated process simultaneously with the Grafcet proposed; several tests for self-diagnosis; and several areas for file download and examinations results. Additional links to other important sites related to Automation are available. The student can access the teacher by e-mail.

A web-assisted package for Process Control studies simulates different real-world systems: electrical, hydraulic, thermal or mechanical, running in open and closed loop modes. Process and control parameters can be changed during simulation. The simulation is run in time domain using integration methods for solving ordinary differential equations. The user can call specific help routines with theoretical support on the subject being studied. Matlab based programs can also be downloaded from the Internet for examples of simulation runs. A simple and easy web page management system has been designed. Every student has access to all Process Control information and, after registration, to personal information previously introduced and managed by the teacher/administrator.

The web packages are still being evaluated by the students. The student uses them for downloading theoretical support, past examinations, animated examples, chat rooms/ forums and on-line questionnaires. Two measurements can be considered to quantify this blended learning solution: students' approved/evaluated ratio and/or average marks; and students' motivation and responses towards the study subjects. The approval rations before and after the e-learning solution implementation are similar, around 70%. What is significant and novel here is students' behaviour and enthusiasm regarding these subjects. The students became, in fact, more motivated and interested in the learning process, developing new learning skills.

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REFERENCES

1. Shank, R., Cleary, C., "Natural learning, natural teaching: changing human memory", Morowitz, H. J., Singer, J.L. (eds.): The Brain and complex adaptive systems. Santa Fe Institute Studies in Sciences Complexity, vol. XXII, Reading, M.A. Addison-Wesley, 1995.

2. Leão, C. P., Teixeira, S. F. C. F., "Utilização de serviços Web no ensino de engenharia", XIV Congresso da Ordem dos Engenheiros – Ensino da Engenharia, Coimbra, Portugal, 2002 (in Portuguese).
3. http://www.easy.uminho.pt/. Accessed on April 20, 2006.
4. Brogan, P., *Using the web for interactive teaching and learning*, Macromedia white paper, 1999.
5. Gonçalves, A., Urbano, M., *Flash MX: Design, animação e programação*, Centro Atlântico.PT, Colecção Tecnologias, 2003.
6. www.tecatlant.fr/grafcet. Accessed April, 2006.
7. http://perso.wanadoo.es/kiko2000/exein_es.htm. Accessed April, 2006.
8. www.automation..hut.fi. Accessed April, 2006.
9. Arantes, F., Dias, F., Soares, F. O., "The Internet as a Complementary Tool for Automation Teaching and Learning", *Proc. of the 12th Mediterranean Conference on Control and Automation* MED'04. Kusadasi, Aydin, Turkey, 2004.
10. Mhandi, M, Braham, R., Moalla, M., Saliah-Hassane, H., "A Virtual Verification and Execution of Grafcet using VRMK", *Innovations 2004*, W. Aung et al. (eds.), iNEER, Arlington, VA, 2004, pp.381-397."
11. Moreira, A., Mota, A., Leão, C. P., Soares, F. O., Web-site Process Control: an extension to the traditional course, *Proc. of the 12th Mediterranean Conference on Control and Automation* MED'04. Kusadasi, Aydin, Turkey, 2004.
12. JavaTM 2 SDK, Standard Edition Documentation, Version 1.4.0, Sun Microsystems, Inc. (2002), http://java.sun.com/docs/books/tutorial/ index.html.
13. Flanagan, D., *Java in a NutShell*, A Desktop Quick Reference for Java Programmers, O'Reilly & Associates, Inc., 1998.
14. Barreto, M., *Aplicações Web com PHP*, Aracaju, 2000.
15. MySQL, Reference Manual, MySQL AB, 2003.

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