

# Experimenta@FEUP

Maria Teresa Restivo<sup>1,2</sup>, José Couto Marques<sup>1</sup> and Tito Vieira<sup>1</sup>

<sup>1</sup>Universidade do Porto, Faculdade de Engenharia

<sup>2</sup>IDMEC – Pólo FEUP

Rua Dr. Roberto Frias, 4200-465 Porto

trestivo@fe.up.pt, jmarques@fe.up.pt, tito@fe.up.pt

**Abstract** - The work describes the two year Project "Experimenta@FEUP" at Faculdade de Engenharia da Universidade do Porto and the actions currently undertaken with the purpose of establishing links with other higher education institutions in the promotion of experimental tools in engineering education. Initiatives aimed at high school students are also mentioned.

**Index Terms** – Engineering education, ICTs in the classroom, Remote laboratory, Virtual laboratory.

## INTRODUCTION

Many engineering projects are nowadays markedly interdisciplinary. It is therefore essential to develop the students' capacity to move with ease across several distinct engineering areas. This can be stimulated by the use of carefully selected interdisciplinary and multidisciplinary case studies which provide a powerful antidote to the increasing specialization of modern engineering curricula with its tendency for an excessive fragmentation of teaching subjects [1].

A Project for the Exploration of Multidisciplinary Problems in Engineering (EMPE) [2], whose main objective consisted in promoting the involvement of teachers, researchers and students from several Departments of FEUP in the exploration of practical problems integrating specialized know-how from various scientific areas, was carried out at FEUP from April 2003 to December 2005. This aimed at developing the undergraduate students' capacity for dealing with diverse areas of knowledge, either scientifically, socially or psychologically. It offered some student training in polyvalence and proficiency, essential skills for tomorrow's responsible leaders on the industrial scene [3]. Finally, it intended to disseminate active/collaborative and project based learning practices. In spite of the almost symbolic funding provided by FEUP there was a significant involvement of students as well as teaching and research staff, with Project EMPE activities extending to other faculties of the University of Porto and to other universities and higher education institutions in Portugal and abroad.

The outcomes and the momentum achieved with EMPE led to the launching in 2006 of a new two year Project, "Experimenta@FEUP" with two main objectives:

(i) Promotion of the use of Information and Communication Technologies (ICTs) in the teaching/learning environment, with particular emphasis on the development of remote and virtual laboratories for widening the availability of experimental tools, contributing in this way to increase the experimental component in the learning process. This has

required the identification of the state of the art for the selection of adequate development strategies concerning hardware, software, sound and image technologies, web seminar facilities, booking tools, support platform and web server management for remote applications and image.

(ii) Consolidation of an educational site for the dissemination, particularly among High School students, of several multi and interdisciplinary activities carried out at FEUP in recent years. This is specifically aimed at young people, as a contribution to help reverse the continuous reduction of newcomers to science and engineering, an emerging trend causing serious concern in Portugal and elsewhere.

The project supports four scholarships working in the above mentioned fields and involves teachers/researchers from all engineering areas as well as from the FEUP Computer Centre. The team is in charge of finding additional funding for other related works.

This paper describes the actions currently being carried out, with the purpose of establishing links with other higher education institutions in the promotion of experimental tools in engineering education.

## eLABS@FEUP

All the activities referred herein as well as those correlated with them may be accessed at eLabs@FEUP with the address <http://eLabs.fe.up.pt>, Figure 1.

This site lists other URLs according to their chronological appearance. It is organized as a structured repository of several project outcomes making sure that their old website addresses continue to lead to the respective original contents.

The site uses a free software package – Drupal - that allows an individual or a community of users to easily publish, manage and organize a wide variety of content on a website.

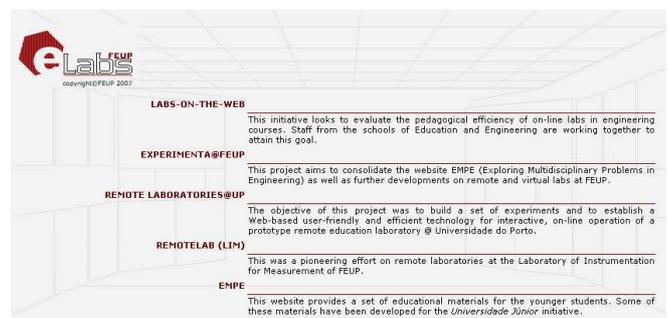


FIGURE 1  
eLABS@FEUP HOME PAGE

For remote experiments using LabVIEW, due to the limitations of the technology used currently, there is a problem. When several users are accessing the same experiment, only the first to access it will get control. The others will be warned that another user has gained control of the experiment.

To deal more adequately with this situation a booking system has been developed at FEUP [4], as an extension of the Moodle platform. At the moment it provides one hour time slots. If the user does not arrive within a pre-defined tolerance period, the Moodle extension will free the previously reserved time slot. The use of Moodle brings additional advantages for storing tutorials on the subjects. Some of the virtual components may be freely downloaded.

## REMOTE AND VIRTUAL LABS AT FEUP

The Laboratory of Instrumentation for Measurement (LIM) at FEUP has been actively committed to the production of thematic e-learning courses [5]-[8] and to the promotion of the use of ICTs in the classroom in the form of remote and virtual laboratories. The next paragraphs will briefly describe the involvement of LIM in setups and simulations under development at FEUP as remote and virtual laboratory components.

At the present I/O cards from National Instruments are used for communication of the setups with the PC and the applications for remote monitoring, control and actuation are developed in LabVIEW 7.1. The built applications create user friendly interfaces for easy remote actuation, while implementing locally the control actions.

### I. A Temperature Calibration Procedure

The system is dedicated to demonstrate a metrological temperature calibration procedure within a selectable range of temperature. In the present case a PT<sub>100</sub> two wire transmitter system is submitted to temperature calibration within a selectable range of temperature.

Figure 2 shows the remote user interface (RUI) for monitoring and actuation, incorporating image from an USB webcam, allowing the user to follow remotely the evolution of the experiment.

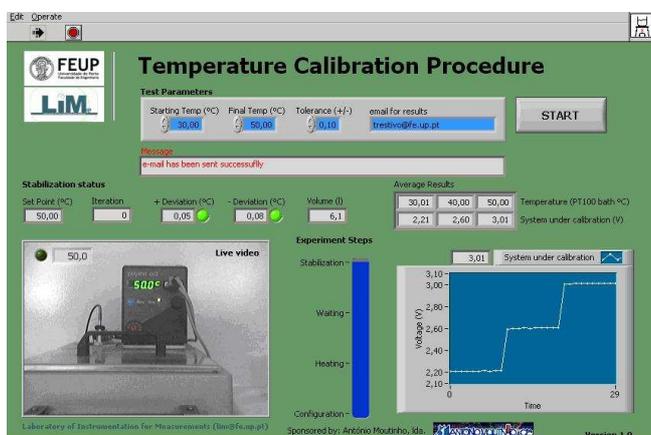


FIGURE 2  
RUI FOR THE TEMPERATURE CALIBRATION PROCEDURE

### II. Mechanical Material Characterization

A cantilever beam instrumented with resistance strain gauges is loaded by a linear motor. The system may be used remotely for automatically measuring force, strain and deflection and it may also be actuated in a manual mode for monitoring the cantilever beam system performance.

Figure 3 represents the user interface available for remote actuation. The Flash Communication Server is used for the USB Webcam. The user interface integrates the LabVIEW interface, live video and an image representing the real system.

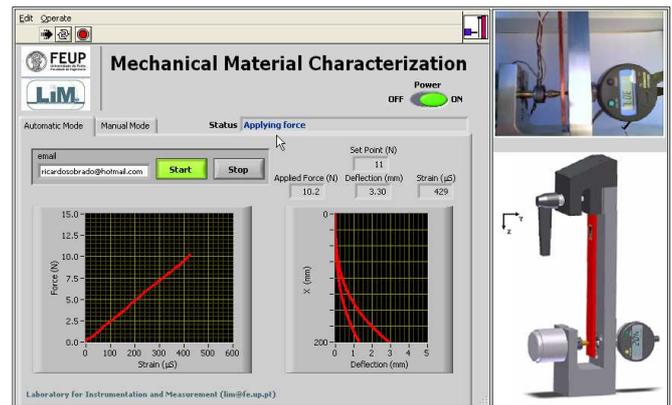


FIGURE 3  
RUI FOR MECHANICAL MATERIAL CHARACTERIZATION

### III. Straightness Evaluation

The straightness evaluation system uses a digital gauge moved by a linear motor through a timing belt element, communicating with the PC by an RS232 interface. Two switches, of electromagnetic reed type, are used as security limits for the range measuring length.

Figure 4 shows the remote user interface, integrating live video from an IP camera.

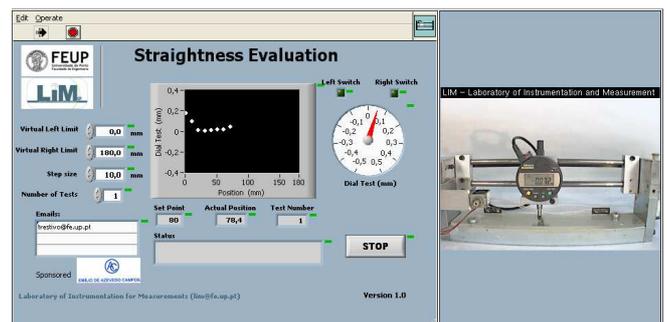


FIGURE 4  
RUI FOR STRAIGHTNESS EVALUATION

### IV. Level Measurement and Control

A system based in a closed loop circuit of two water tanks is used for remotely testing different control algorithms and comparing the performance of diverse level transducers and level transmitters.

Figure 5 illustrates the user interface for remote monitoring and actuation, including live video from an IP camera.

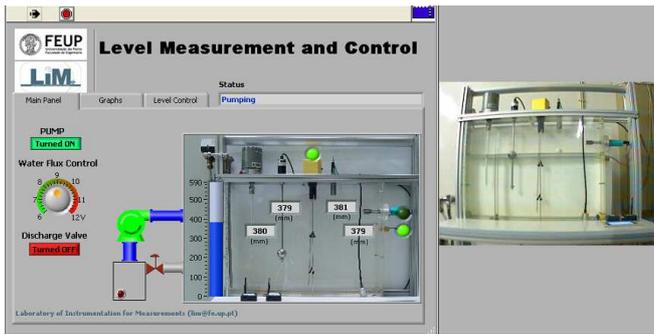


FIGURE 5  
RUI FOR LEVEL CONTROL

### V. Meteorological Station at FEUP

This sensitive remote laboratory aims to contribute to the urban climate characterization of Porto. Several physical quantities (temperature, wind velocity and direction, pressure, relative humidity, radiation intensity and rainfall) within the Campus of FEUP are available every 10 minutes. All the data is recorded in a data base for later use by anyone accessing the system. A special IP Camera for outside use and for night visualization is feeding the site, Figure 6.



FIGURE 6  
RUI FOR THE METEOROLOGICAL STATION

### VI. Michelson Interferometer

This system permits the user to measure displacements with the resolution of one half of the laser emission wavelength as a consequence of the Michelson interferometer working principle.

Figure 7 shows the remote user interface for the Michelson interferometer.

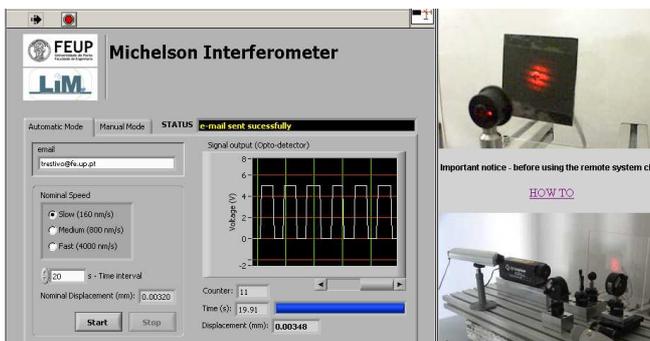


FIGURE 7  
RUI FOR THE MICHELSON INTERFEROMETER

The simulation of Figure 8 explains why the light fringe pattern occurs, showing the different physical reasons and allowing the student to interact with them, observing them separately or combining them.

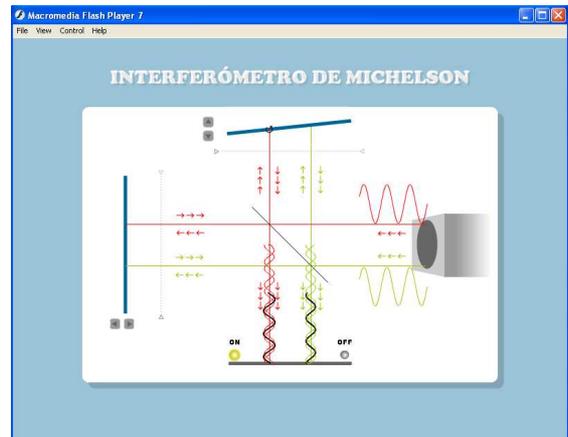


FIGURE 8  
FRINGE PATTERN SIMULATION

Figure 9 offers a very flexible virtual interferometer, permitting the selection of laser beam wavelength (this means selecting the laser!) and performing the complete procedure of tuning the interferometer before using it for displacement measurement. This possibility is very important because tuning such a system is a step difficult to understand for students.



FIGURE 9  
RUI FOR THE VIRTUAL MICHELSON INTERFEROMETER

### VII. Structural Mechanics Workbench

The structural test frame depicted in Figure 10 can either be present in the classroom or, alternatively, it can be accessed as a remote laboratory facility using voice and video communication technologies readily available at present, such as Skype® and an IP network camera for demonstration during theoretical sessions.

The test frame accessories comprise several support types, a set of weights and various metallic beams, with which simple structural configurations can be set up and loaded in order to compare the reaction forces and the beam deflections with the theoretical values.



FIGURE 10  
TEST FRAME FOR STRUCTURAL MECHANICS

A virtual system to complement and further enhance the didactic test frame prototype was also produced, Figures 11 and 12.

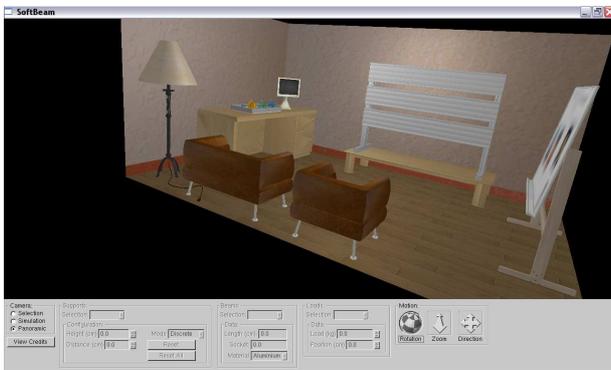


FIGURE 11  
THE VIRTUAL ROOM

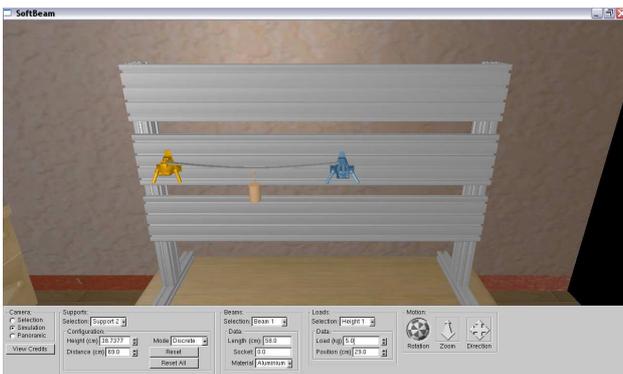


FIGURE 12  
THE VIRTUAL STRUCTURAL MECHANICS WORKBENCH

For most of the reported experiments the user will get the test result for later data processing by introducing the user email address on the interface email address field. Also, for the same experiments and each time its remote control is required a sensitive system measures the room light intensity and switches on a light if necessary. Also, all the setups hardware is automatically powered on and off each time their remote control is asked or released, for saving purposes and equipment life protection.

Other experiments have been developed at FEUP but not under the direct responsibility of the authors. All of them will be found at the eLabs@FEUP site.

## EMPE SITE

The site aims to offer activities for high school students and also for the general public. They have been developed by students/teachers/researchers in the course of the EMPE Project. One of them presents an everyday life object – a beverage can. It has been explored in many different perspectives and has shown how such a familiar object can be a rich matter for discussions. Some of the contents have been used on Universidade Junior activities [9], at the Mechanical Department at FEUP. Figure 13 presents one of the proposed activities.



FIGURE 13  
BEVERAGE CAN ACTIVITY

## FEUP NETWORK COMPONENTS

The main Network Components that helped bringing the Experimenta@FEUP Project to reality are the Firewall Security Infrastructure and the bandwidth management system, whose configuration is shown in Figure 14.

From a security point of view, the project posed several challenges concerning the security levels that had to be kept sufficiently high in order not to compromise the whole infrastructure. The firewall used to protect Experimenta@FEUP and the rest of the FEUP campus is based on a cluster of machines running Checkpoint NGX. This security infrastructure had to be configured to allow traffic to pass from the internet directly to the lab experiments, using special Web Intelligence features to guarantee that no malicious code could be passed through the web services supplied to the end users. Various problems were encountered and solved directly by the FEUP Computer Center team, while some of them needed additional help from Checkpoint Research & Development teams from Israel.

The FEUP network management control is Internet Link using an Allot NetEnforcer. This infrastructure provides a granular visibility and dynamic control to optimize the delivery and performance for special project requirements like those of Experimenta@FEUP. For this purpose network policies were implemented to guarantee the Service Level Agreements to the standard necessary for the whole project to run smoothly, even under high bandwidth level usage

prioritizing the traffic to meet the high Quality of Service needed.

This project can be considered a success both security wise as well as in terms of connectivity enhancements to accelerate packets used for the multimedia components of Experimenta@FEUP.

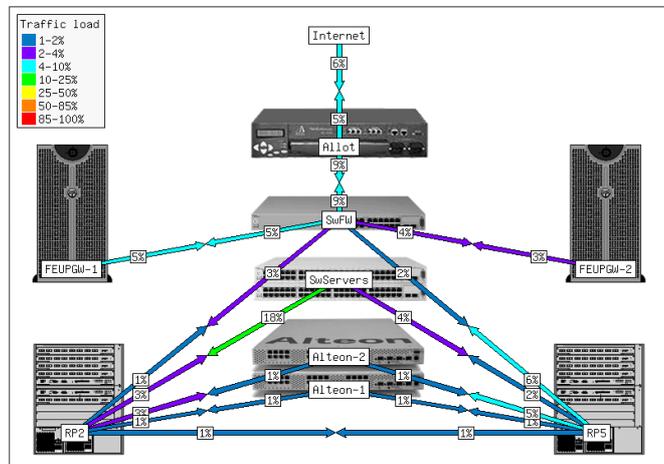


FIGURE 14

THE BANDWIDTH MANAGEMENT SYSTEM AND FIREWALL INFRASTRUCTURE DIAGRAM

### FINAL COMMENTS

The main purpose of Experimenta@FEUP is to consolidate the knowledge of students by offering complementary training opportunities on experiments and also sharing with other institutions. In fact, if consulting the famous Portuguese site “O Pio do mocho”, a well known site in our country, one can observe the connection to some of our experiences. Similarly, on the Mechanical Engineering Department at University of Coimbra, the students are using these experiments on their course of Instrumentation for Measurement. Also, at the Secondary School Mário Sacramento at Aveiro, one the staff members is now introducing his students to accessing experiments by the web and is working out the production of new experiments dedicated to those specific students. On the other hand, colleagues from the Faculty of Education Science of Porto University are studying ways of evaluating how these materials could be relevant for teaching/learning activities. This gives additional confidence to the authors regarding the effectiveness and pertinence of Experimenta@FEUP.

### ACKNOWLEDGMENT

The authors wish to express their gratitude to the Board of Directors of FEUP for the support provided. The first author acknowledges the invaluable contribution of the LIM team for many of the results shown in this paper.

### REFERENCES

[1] Silva, A.F. et al., "Interdisciplinary projects in the teaching of computer science" ("Projectos interdisciplinares no ensino de ciência da computação"), *I WEIBASE*, Faculdade Senac de Ciências Exatas e Tecnologia, São Paulo, Brazil, 2003.

[2] Marques, J.C. and Restivo, M.T., "Interdisciplinarity at FEUP", *Proceedings of SEFI 34th Annual Conference*, Session 2, pp. 264, ISBN 13: 978-91-631-8387-4, Uppsala, Sweden, July 2006.

[3] Thiollent, M. J-M. et al., "The subject of interdisciplinarity in the production engineering", *Programa de Engenharia de Produção*, COPPE, ICEE, UFRJ, 1998.

[4] Ferreira, J.M. and Cardoso, A., "A Moodle extension to book online labs", *REV 2005 - Remote Engineering and Virtual Experimentation Symposium*, Brasov (Romania), June 2005.

[5] Restivo, M.T., Carvalho, I., Mendes, J., Magalhães, R., Gróf, G., "Remotely visiting academic labs using ICTs", *Proceedings of SEFI 34th Annual Conference*, Session 4, pp. 64, ISBN 13: 978-91-631-8387-4, Uppsala, Sweden, July 2006.

[6] Teixeira, D. D. et al., "A Michelson interferometer for a virtual laboratory", *M2D'2006 - 5th International Conference on Mechanics and Materials in Design*, CD-Rom Proceedings, Session 10-E, Edition INEGI, ISBN: 972-8826-10-9, Portugal, 2006.

[7] Restivo, M.T. et al., "E-teaching mechanical material characteristics", *M2D'2006 - 5th International Conference on Mechanics and Materials in Design*, CD-Rom Proceedings, Session 10-E, Edition INEGI, ISBN: 972-8826-10-9, Portugal, 2006.

[8] Restivo, M.T., Almeida, F.G., Chouzal, M.F., Mendes, J.G. and Lopes, A.M., "Instrumentation for Measurement: a bilingual e-book", *ICECE'2007 - International Conference on Engineering and Computer Education*, CD-Rom proceedings, ISBN:858912042-2, Santos, Brazil, 2007.

[9] Gomes, J.F., "Universidade Júnior: a project to motivate school pupils", *ICECE'2007 - International Conference on Engineering and Computer Education*, CD-Rom proceedings, ISBN:858912042-2, Santos, Brazil, 2007.