Utilization of Interactive Internet in High Education

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Abstract: The present work reports on the practical cooperation between two Universities from Hungary and Portugal. Students from Portugal are remotely accessing an experimental facility, which is physically in Hungary. The cooperation among these Higher Education establishments allowed the development and testing of a Remote Laboratory at the BME. This paper reports on the characteristics and initial testing of the Thermocouples Rise Time Measurement System and provides information on development and students’ feedback.

Key-words: -Remote Laboratory, Engineering, Distance Learning, Computer Based, Thermocouples

1 Introduction

Promoting international cooperation in Engineering Education is of high importance in these days of “global engineering”. It not only increases students’ awareness and motivation as well as exposes them to other Education systems, curricula and learning tools. The practice side of Engineering Education requires the development and maintenance of expensive laboratories, which are of major importance at both BSc and MSc levels. The utilization of Remote Laboratories can be of great assistance for inter-university cooperation at National and International level and allow including other facilities that are not physically hosted by all the partners involved. The already existing laboratories can be shared among universities allowing additional possibilities for the students to make individual tests. The students are able to get acquainted with the test rigs and with different measurement techniques and calculation methods and have an actual insight on what is being done in other Universities and countries in the same or different Engineering degrees. The use of distance learning techniques and of practical educational tools, as Virtual and Remote Laboratories \cite{1-3}, allows for the promotion of new methodologies and tools in Engineering Education.

Web-based assignments allow for additional perspectives not possible in a laboratory setting and allow the learner to proceed through an experience during a broad time period not fixed by a regular class schedule and makes learning more interesting and flexible \cite{4-7}.

Both partners dedicate special attention to the use of ICT in Engineering Education within different contexts and methodologies but with general common goals and within a close collaboration which started a decade ago and has more recently evolved into the sharing of resources and tools \cite{8}.

The Portuguese partners have been involved in the development and use of both Virtual and Remote Laboratories. This ongoing work was mainly motivated by the need to illustrate theory-based lecture content with practice and real-world applications and the need to efficiently serve a large class within mandatory courses with a large syllabus.

The Laboratory of Instrumentation for Measurement (LIM) at FEUP is mainly devoted to system sensorization, measurements and meteorological procedures and system automation. LIM has dedicated special attention to the production of thematic e-learning courses and their off-line versions as well as to the development of remote and virtual laboratory components, always on a blended learning base. These applications have been used for complementing student knowledge on experimental tasks or as a side task prior to or following real lab sessions for consolidating and promoting experimental activity \cite{9-12}.

Finally, the present approach is also integrated in a wider educational driven project as the attempt to design, implement and develop new teaching and learning methodologies, which promote active and collaborative learning \cite{13-17}.

This paper describes the implementation of a Remote Laboratory, the Thermocouples Rise Time measurement facility at the Department of Energy Engineering at the BME and the testing and feedback from students in Portugal.
2 Remote System Developments

The “Jendrassik” Heat Engines Laboratory at the Department of Energy Engineering at BME can be divided into two categories from the control point of view: i) there are instruments and systems which can be fully controlled with the use of the internet which do not require special staff for their safe running and the service costs are low as well, and; ii) there are several experimental facilities which cannot fully be controlled through the internet and require special staff attendance to run and have high service costs. The latter play a great role in the Department of Energy Engineering (BME) because they are used for practical demonstrations and student’s mandatory practical assignments.

After careful consideration the Department decided to build up two remote laboratories, of distinct characteristics, applications and teaching and learning objectives.

The “Thermocouples rise time measurement system” was chosen for the “full” remote access and the “Lang” steam turbine was selected for “partial” remote utilization.

2.1 Control software of the measurement system

The basic structure of the remote laboratory is shown in Figure 1. The major parts are:

i) A/D converter which belongs to the Thermocouples rise time measurement system, connecting the controller with the measurement computer;

ii) A fully dedicated computer which provides the measured data for the database and web server;

iii) A PHP-based web application running on the server, which provides data for the learners / clients, on which the remote laboratory system can be used with the help of a simple browser.

In the present case LabVIEW\(^1\) 8.5 software is used as measuring and measurement controller software. The aim of this software is to transfer the measured data to the database and to carry out its commands on the measurement device.

A booking system, shown in Figure 2, was established on the website allowing access to the Remote Experiment to assist students in organizing their schedule for the tests. The booking system allows a time window to be fixed for each individual (student) measurement. Users can register as students or instructors. Instructors are able to reserve more appointments (time windows) at once. The results of the measurements are downloadable in MS Excel file format.

At the present stage the Thermocouples Remote Experiment can be accessed in three different languages (Hungarian, Portuguese and English).

Since accessing the remote desktop is very easy, it might be used as a tool for users for controlling the measurement [18]. Implementing such a way the remote laboratory needs a very strict discipline to prevent that a user doesn’t stop the on going experiment of another user. To avoid the problem of simultaneity we use the booking system not only assist for users in organizing their schedule as it was mentioned. Another technology in preventing users in interruption is the PHP–based web application instead of the simple remote desktop method.

2.2 The thermocouples rise time measurement system

The aim of this experiment is to examine the dynamic behaviours of thermocouples with different

\(^1\) LabVIEW is registered trademark of National Instrument Co.
constructions and emissivity when exposed to the same amount of heat radiation or temperature change. The experimental facility is shown in Figure 3. The equipment includes four different thermocouples. These are:

1. (ø 1,5 mm) thin, reflecting shielded thermocouples
2. (ø 1,5 mm) thin, reflecting thermocouples
3. (ø 3 mm) thick, (ε≈1) black thermocouples
4. (ø 3 mm) thick, (ε≈0,2) reflecting thermocouples

Figure 3. The Experimental Facility – Thermocouples Rise Time

The four thermocouples are inside a short “tunnel” and are 10 mm apart from each other. The bottom of the system is equipped with a ventilator (fan) and an electro-heating unit. These devices can be controlled by three switches as shown in Figure 4:

- The first switch turns on the ventilator which causes a continuous air flow in the “tunnel” and creates a quasi-isothermal environment;
- The second switch turns on half power of the electro-heating unit, and;
- With the third switch the whole power of heating unit can be turned on. The left side of the system is equipped with an infra-lamp which can be turned on and off independently from the heating unit or ventilator. With the help of the infra-lamp all thermocouples can be radiated with the same amount of heat.

Figure 4. User surface of the Thermocouples rise time measurement system

It is important to know that the temperature change is dependent on time. During the measurement the student can switch on and off the equipment (the infra lamp, electro-heating unit and the fan) following the measured temperatures of the four thermocouples in a plot. Figure 4 shows sample results of the measurements as well as indicate the time of the interferences. After the measurements the results can be downloaded in a CSV file and student will use it for related requested calculations. This experiment allows students to learn about the importance of the time constant and the effects of the dynamic properties of the sensors on the results of the measurements. The graphical and numerical calculations method helps students to understand the order of magnitude of the time constant and compare or contrast the theoretical (model) results with the measured (real) ones.

2.3 Steam turbine remote measurement

The “Lang” steam turbine and its original measurement system were installed in the laboratory of the Department in the 60’s and were renovated in 2007 with the help of ALSTOM. To simulate the load an eddy-current break was installed in with which we can carry out measurements at different speeds. The speed and torque measurements are carried out by the break regulatory system. After the retrofit we created some measuring points for the measurement of pressures and temperatures for following the thermodynamic states of the expanding steam in the turbine. For teaching purposes in higher education and vocational training it is very important to have a steam turbine with the same control and protection as it is applied in the industry. Thus, the most important elements of the control are integrated into the
measurement system, such as the governor oil pressure.

Although with the help of the measuring system the entire measurement of the steam turbine can be controlled through the internet, a special staff is required to run the process (to start the steam turbine, open and close the main valve of the steam pipe, etc.). Therefore, students using the remote lab have access only to record thermodynamic properties during the measurement but have no access to control them. There are two web cameras installed in the laboratory. One has a picture about of the steam turbine, the other one follows the governor valve in operation. Before a measurement an appointment has to be booked because of the steam demand.

Figure 5. The “Lang” steam turbine after retrofit

During the measurement the user of the remote lab can observe the measured data and the two images of the measurement provided by the webcams. The user can call the staff over the Internet with the help of a freeware (such as Skype®) and ask them to modify the parameters of the steam turbine.

3 Implementation and testing

The kick-off work consisted on the outline of general and specific objectives, mobility calendar and deadlines. The thermocouple rise time measurement remote laboratory development started at the Department of Energy Engineering at the BME and several discussions followed. Later on a Portuguese student spent one month at the Hungarian partner University to participate in the development and implementation the access website. Simultaneously, Hungarian, Portuguese and English versions of both the Experimental Description and other relevant information were written and checked.

After the initial tests performed at a distance for several months the Thermocouples Rise Time Measurement System was considered to be ready for trial. Here, objective and simple guidelines (Read me first) were written for the Portuguese students at ISEL and a questionnaire was prepared which is targeted for structured feedback and analysis.

The one page guidelines included browser, URL and registration information along with suggestions on how to proceed (paths) in terms of background information and booking system were also ready for use. The students described here take Energy Production and Management as a compulsory subject over one semester in the first year of their Master degree course in Mechanical Engineering. Although the specific experiment is not a part of this course curriculum the students have the necessary background to understand the Thermocouples experiment. In-class information was also provided concerning the cooperation project and objectives and answers were provided to students’ up-front questions.

The students were requested to perform the Remote experiment within two weeks time and to provide continuous feedback on any type of doubts and problems encountered. It should be mention that this was the first time that all these students were involved in a Remote experiment. Finally, there were asked to upload their Lab report and questionnaire into the appropriate Forum used within a proprietary Learning Management System (LMS), which is being used for the Energy production, and Management [14].

Due to a few time constraints and software problems the majority of the students achieved to successfully complete the requested work after a three week period. As an overall and initial analysis from in-class discussions and from the structured questionnaires the students considered this experience to be a positive one!

The one page questionnaire was divided in two parts: Remote Lab Evaluation and Global Evaluation and Suggestions. The first part addressed questions as: i) access, comprehension, theoretical background provided and Excel data file, and; ii) concepts, practices, methodology and tools. The second part addressed questions as: i) personal experience; ii) skills and development; iii) three positive aspects and three less-positive aspects of the experiment, and; iv) other suggestions.

Concerning the first part of the questionnaire, over 80% of the students considered the access and comprehension to be adequate (easy) but gave a lower grading on the theoretical background provided, as they expected more detailed information. This is obviously related with the different degree curriculum at Institutional level and the fact that the students at ISEL...
are not requested to perform experimental work when thermocouples are concerned. All students gave the highest grading to the opportunity they were given to get acquainted with new practices, tools and methodologies in detriment of concepts.

As to the second part of the questionnaire, 80% of the students favoured the personal experienced when opposed to the skills and development one. Once again, this result might be different if the students were carrying out the thermocouples experiment framed within the appropriate course.

As to the three most positive aspects the students mention (quote):

i) the possibility of real time plot visualization;
ii) international cooperation;
iii) easy to carry out;
iv) possibility to do it online;
v) new, interesting and innovative.

The three less positive aspects included (quote):

i) experimental description not totally clear;
ii) some difficulties in accessing the remote experiment;
iii) the need to choose a time-window.

4 Conclusions

There are number of different reasons why the remote laboratory technology is applied in those institutions where the experiment presentations or self-dependent laboratory practices are the vital parts of the curricula. Implementation of the remote laboratory needs more efforts (manpower, time, economic support, etc.) than a simple physical set-up of the remotely accessible test facility. However, it is a very good field for national or international cooperation since there are several tasks that need everyday contacts and collaborations as well during the implementation period and during the operations. The multi language implementation helps in collaborations and for achieve a certain quality level it needs the international collaborations as well.

It is expedient to configure different starting points for the remote laboratory users according to theirs previous knowledge level. The students will be made inactive, that’s all, if in a real laboratory practice they have to run through again on the known parts and independently of that the instructor will conduct them through the whole experiment-measurement tasks. It should be taken into account that the part of the users may omit those parts that they believe to be known.

It should never underestimate the work has to be done during the making of the remote laboratory syllabus since it never means a simple web implementation of the existing real laboratory guide since it does not and could not contain those information that are handled over in the face to face contacts during the real laboratory activity. The content development could not seem to be closed with finalization of the technical implementation. Already in the planning period should be worked out the proper feed-back system in order to keep and maintain the hardware and software sides of the remote laboratory taking into account the user opinions and feed-backs.

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