

Virtual Web and Experimental Vibration Laboratory Coordination as an Educational Tool for Mechanics Teaching in Engineering

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Abstract—The purpose of this paper is to evaluate the effectiveness of using virtual laboratory as a complementary tool for mechanic teaching. The use of Virtual Oscilloscope Web and Virtual Damped Oscillations Laboratories, together with the study of the vibration of beams Experiment in a real Laboratory in the university teaching system, are explained. The computer programmes can be used from the online and download areas of the Applied Physics and Mechanics Departments internet server, in order to be executed via web. These computer applications permit one to simulate practice behavior, and the users can work step by step in the same way as they do in the real laboratory, obtaining the corresponding calculations and plots. The Virtual Laboratory Web has been developed by our research team and the main objective is to familiarize the student with the oscilloscope and the Damped Oscillations experiment for its later handling in a real laboratory. The aim of these tools is to help students to learn, to study, and to investigate on their own. Furthermore, students can prepare their experiment lessons before going into the laboratory and revise them whenever, and as many times as they want to. Consequently, in using the computer as a complementary educational tool, the quality of university teaching is greatly improved.

Keywords—Education; Technology; Simulation Software; Multimedia; Oscillations; Virtual Laboratory.

I. INTRODUCTION

In the past twenty years, there has been widespread experimentation with computer-assisted didactic models in the training of highly qualified experts such as aircraft pilots, astronauts and engineers specialized in controls. The same has happened in teaching centers using models, which allow the computer to emulate the working of different laboratory equipment and to instruct students, how to use it.

The carrying out of these experiments in the Mechanics teaching laboratory is very costly and requires students to devote considerable time to the study of each of the experiment facilities and to the handling of the equipment. In the Laboratory of the Mechanics Department at Córdoba University, we have two real vibration bench practices that we use to study the natural frequencies of simple beams (Isostatic beams as cantilevers, articulated beams, etc.) with or without damping vibrations.

However, due to severe overcrowding in classrooms and not enough necessary time, we have been developing and using a virtual lab that shows the real practices to the student.

This paper presents a new learning experience of the coordination between the virtual laboratories and the real experiment in the beams vibration practice.

Firstly, we describe two virtual laboratories developed by our research team: the virtual web oscilloscope and the virtual Damped Oscillations laboratory.

Furthermore, we present their application to the practice in the Mechanics Laboratory and we analyze the results obtained by the students in the practice classes.

II. STATE OF THE ART

Currently, a lot programmes for the simulation of certain important Physics experiments have been created [1], whose worth lies in contributing to the students' capacity to perform, in a simplified manner, those mental actions which are similar to those that they might have to carry out in a traditional laboratory, with the aid of these models.

From a general point of view, numerous applications exist whose main objective is education and the transmission of knowledge [2]. The use of the computer for such an aim accelerates the learning process of the concepts dealt with, since the interaction with the user allows them to be assimilated in a more rapid and easier way [3].

In the field of scientific and technological education, the computer can be used as a reflective tool, where the student is a protagonist of his own learning process [4] [5].

From this perspective, our line of work has focused on the development and evaluation of applications that include different modules: diagnoses of knowledge and previous ideas, resolution of problems, numerical simulations, virtual laboratories, interactive tutorials, etc. From an educational point of view, the principal didactic usefulness of the tool presented is that simulations of the phenomena and virtual experiments offer a certain degree of realism so that the student can modify the independent variables or the initial conditions and can analyze the changes that take place in the systems [6].

The development in the Departments of Applied Physics and Mechanics at the Polytechnic School of Córdoba University (Spain) of computer applications for didactic

purposes began during the academic year of 1988-1989. From the 1991-1992 academic year onwards, the imparting of practices simulated together with the experimental practices has been generalized. This methodology is applied in the learning of Physics and Mechanics in the first years of Industrial Engineering and Computer Engineering [7].

For all these reasons, our group has been involved in the development, application and evaluation of virtual laboratories and their utilization, with a series of encouraging results that have been described in other works [8].

III. OBJECTIVES

The purpose of this study is to evaluate the effectiveness of using virtual laboratory as a complementary tool for mechanic teaching. For that, an objective is to coordinate virtual web and experimental laboratories.

Also, another objective is to familiarize the student with the oscilloscope and the Damped Oscillations experiment for its later handling in a real laboratory.

These tools help students to learn, to study, and to investigate on their own.

The computer applications include Interactive tutorials, and Questionnaires, which give students the possibility of evaluating themselves.

IV. TEACHING EXPERIMENT DESCRIPTION

Before doing the practices, the student downloads the programme guide from the learning web of the Mechanics Department, in which a brief introduction is given on the theoretical fundamentals, recommending the student to consult the virtual laboratories [9] [10], the tutorials [11], the apparatus, and the operating mode of the experiment.

On the day that the experiment takes place; the student has to take a brief summary to the laboratory to be handed in the moment the experiment begins. If possible, the student is recommended to take a portable computer to the laboratory so that there is one per 2 students (one for each work post). The teachers also provide them with two computers.

The students carry out the experiment processes by consulting the operating mode in the virtual laboratories and checking the results obtained experimentally with those that they would obtain by simulation. Finally, students have to hand in a final report of the practical, in which they include the data treatment, results obtained and conclusions.

V. SOFTWARE TECHNICAL DETAILS ON THE TOOL/SYSTEM

The damped oscillation software has been created using Visual Basic 5.0 language, with the aim of making the user feel that he/she understands and has a good command of it since we have tried to make it very intuitive and easy to use. The Oscilloscope programme has been created with Action Script and it permits user-software maximum interaction via web.

Both programmes are in research team VLC web server [10] [11].

VI. SOFTWARE PROPERTIES

The interface of the computer applications must be the simplest, most intuitive and most attractive possible, so that it allows the user to interact with the machine and to obtain an ideal execution of the presentations that the application developed offers [12]. The characteristics of our system are described as follows:

- *It facilitates the user's browsing for the different parameters included in the application; presenting them in a form arranged in such a way as to avoid confusion.

- *The elements of the interface are accommodated so that their position on the screen facilitates the transition between the thought of the user and the action to be carried out.

- *The application is intuitive and attractive.

- *There is an exhaustive control of erroneous information so that mistaken results cannot be returned to the users without providing informative messages about the mistake committed.

VII. OBJECTIVES OF THE IMPLEMENTED SOFTWARES

The primary target of this work has been to remedy the deficiencies of Technical Studies students at the time of acquiring knowledge. Concretely, in doing practice work in laboratories, especially in that corresponding to experimentation with beam vibrations, for which it is necessary to know how to use with ease an oscilloscope and the experimental handling of damped oscillation equipment.

By means of the virtual oscilloscope, which is included within a more global project of virtual laboratories encompassing different Physics and Engineering problems, the student can become familiar with the handling of an oscilloscope (Figure 1). Other objectives achieved are:

- Objective 1: Multimedia has been developed for a system that includes sample information necessary for students in the Vibrations field.

- Objective 2: It allows the user to become familiar with some of the devices used in the oscilloscope.

- Objective 3: "Multiplatform" works in surroundings; in addition, the application can be used under any platform, or Linux, Windows, etc.

- Objective 4: To reproduce schemes of the real systems so that the students can visualize the problems created.

VIII. DESCRIPTION OF THE VIRTUAL LABORATORY

A. Oscilloscope Virtual Laboratory

The Software [10] is structured in three different sections: Tutorial, Simulation, and Help.

General Interface. The interface of a computer system must be as simple, intuitive and attractive as possible, so as to allow the user to interact with the machine.

Theoretical Tutorial Module. The tutorial is clear and concise, using pictures and diagrams, the basic concepts of the subject matter, the study's scope and its application to the vibrations of simple beams.



Figure 1. Virtual Oscilloscope

Simulation. The main objective of this lab is to learn to use the analog oscilloscope to display and measure periodic signals in time. For this, as shown in the image of the virtual oscilloscope, we have different switches and controls that allow us to modulate the frequency, the amplitude of the signal, and so on.

B. Damping Oscillation Simulation Lab

The study of the vibrations in beams is implemented by an experimental bench with springs.

The practice laboratory that we have implemented in the computer basically consists of a frame on which springs with different elastic constants can be suspended and loads also added. A piston is placed in a vessel which is filled with liquids of different viscosities and a recorder equipped with a pen traces the different types of motion: quasi-free, under damped, critically damped and over damped oscillations. In actual fact, we have tried to simulate the real vibration bench practice shown in Figure 2.

The essence of this application consists of the design and creation of interactive software incorporating the most important experiments that can be done by students with a free and damped vibration bench. This comprises four parts, which can be accessed from the main menu: Tutorial, Simulation, Introduction and on-line Help.

In the simulation module, a study can be made of the motion of a load suspended vertically from a spring in terms of the following parameters: viscosity, system load and elastic constant of the springs. This module is a virtual representation of the instruments necessary for the student to be able to have it recognized and learn how to use the real vibration bench when he/she has completed this practical.

In order to create the multimedia system, a video camera film was made. It displayed both the components of the practical (loads to attach, springs, oils, etc.) and the experimental process itself. The application generates graphic and numerical results. The button "Print" enables the student to print the register of the corresponding motion. The button "Following" makes it possible to go on to any new motion resulting from having modified the conditions of the system. (Figure 3)



Figure 2. The real vibration bench practice

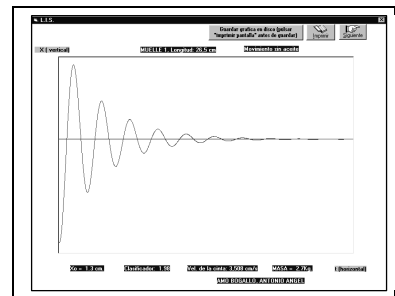


Figure 3. Screen for damped motion generation

IX. EDUCATIONAL APPLICATIONS

We have used these virtual laboratories as complementary tools to traditional teaching methods, with a view to obtaining more personalized teaching to counteract the present overcrowding of university classrooms.

With the aim of checking the degree of influence of the coordination of virtual and experimental laboratories on the learning process, the results of the didactic experiments carried out during the last two academic years were compared.

Of the 160 students enrolled in each academic year, approximately 100 signed on for the laboratories web. This was an indispensable condition for carrying them out.

Of the 100 students who began the course, approximately 90% did the real and virtual experiments, subsequently handing in their reports. This is also an indispensable condition for passing the subject "Mechanics in Engineering".

The assessment of the programmes used was made by evaluating the individual reports of the students at the end of the experiment and some complementary questionnaires on the topics tackled.

This evaluation was analyzed by classifying the results obtained by the students and establishing three categories of knowledge, i.e., abandonment of studies, fails and passes.

The results obtained show (Table 1) that, in the past two years, the number of students abandoning the experiment and virtual laboratories, and, therefore, the subject has dropped. What is more, in the same period during which the virtual Laboratories were increased and coordinated (2010 and 2011), the percentage of students failing diminished,

and the amount of students with improved results in practical works rose. Thus, it can be concluded that the putting into practice and implementation of virtual laboratories in coordination with experimental ones triggers a great improvement in teaching.

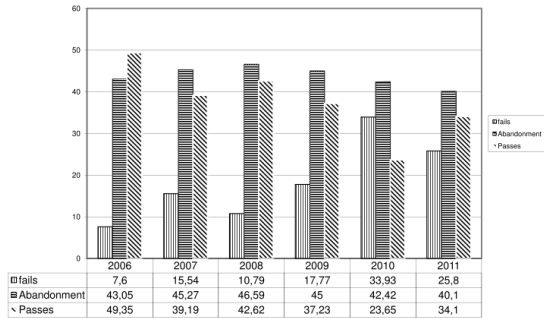


Table 1. Comparison of overall results for subject of Mechanics

X. CONCLUSIONS

This paper has presented the computer applications designed for didactic purposes in university teaching of a scientific and technological nature, which are currently being used and evaluated – in real education contexts – with first-year students of industrial engineering studies at Cordoba University (Spain).

The programmes are equipped with complete tutorials, presented with hypertext and images in order to help students to understand the concepts. These tutorials include animations, sound and videos, which increase their appeal to students, who can browse through the different parts of the Tutorial by means of hyperlinks and buttons connecting different parts of the system.

The simulation and virtual laboratories of real experiments are undoubtedly the most important items of these applications. Using them, students can actively interact: by incorporating data into the independent variables, in the observation of experiments, in the analysis of the results obtained, and in other aspects related to the solution of any problems encountered.

These computer applications are compact, intuitive, and easy-to-use tools, which combine, in a single application, the main elements involved in the education process: theoretical contents, practical activities (solution of problems, simulations, and virtual experiments), and the evaluation of previous or acquired knowledge.

The computer applications have been used as a learning tool incorporating it into the tasks of the course.

The evaluation of the results of student grades has shown that the use of computer simulation tools encourages students' interest in the subject and improves their marks helping to raise their level of knowledge of theoretical concepts and practical teaching techniques and problem solving.

Finally, in future projects we hope to develop 3D Virtual Labs as a relevant solution to immerse the students in a realistic experimental environment.

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