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Virtual metrology laboratory for e-learning

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Abstract

Understanding geometrical specifications is becoming more and more difficult due to the latest developments in ISO GPS (Geometrical Product Specification) Standards, and at the same time, students' learning habits are evolving and theoretical courses on standardized specifications are not attractive. Metrology laboratory work is much more appealing and highlights the difficulties encountered in interpreting specifications and the inherent method uncertainties. Nevertheless, metrology activities require an expensive metrology laboratory equipped with CMMs. In order to carry out real hands-on experiments, Bordeaux University is designing a virtual laboratory framework. It is integrated into Moodle (an L.M.S., Learning Management System) as a new activity to establish a link with other Moodle learning activities (courses, tests, etc.) and to ensure student tracking. A first prototype of the virtual laboratory is dedicated to dimensional and geometrical metrology with simulated traditional measuring devices (gauge, micrometer, dial indicator, etc.) and Coordinate Measuring Machines. Measurement simulation is in a three-dimensional environment and is based on models of parts with dimensions, orientation, position and form errors (skin model shapes) and on models of measuring devices with measurement uncertainties.

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Keywords: ISO GPS; e-learning; virtual laboratory; hands-on laboratory, skin model shape

1. Introduction

1.1. Concerns

Classroom lessons at the University are not always fully appreciated by the students. In traditional forms of learning, through physical attendance, both student learning and teacher motivation may be affected by external stimuli, or simply by lack of attentiveness and interest.

Furthermore, scientific and technological studies are based on the practical application of theoretical learning, through the manipulation of objects and instruments. Practical classes planned for this purpose require a dedicated time slot and an appropriate room. The large numbers of students registered in the first years of higher education, material limitations (number of rooms, facilities) and a lack of human resources make it difficult to learn only by practical exercises in classroom.

Given the evolution of students' attention span, the lack of time and resources for the acquisition of knowledge through practice, one solution is to develop an educational strategy based on a Learning Management System (LMS) integrating a Virtual Laboratory (VL).

Using virtual lab sessions, following different scenarios, teaching classes (lessons or practical exercises) can be prepared remotely to consolidate classroom learning and acquire additional knowledge.

1.2. Existing online laboratories

Online laboratories have been developed for a couple of years now. From a technological point of view, one can distinguish remote laboratories and virtual laboratories.

1.2.1. Remote laboratories

The aim of remote laboratories is to conduct real experiments through internet communication from home or

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anyplace. Remote laboratories are very well adapted to experiments with reduced handling, essentially electronics experiments [1]. The measures on an electrical circuit require just a short time of use of the remote laboratory, and many students can follow one another in rapid succession. Bending a beam [2] is another example of quick measurement in mechanics. Other areas of application for remote laboratories are optics [3] or robotics. Remote laboratories can also be used for expensive experiments or dangerous manipulations. Experiments must fulfil two requirements for remote and wide access: they should be automated and short. This is not the case for dimensional metrology.

1.2.2. Virtual laboratories

Virtual laboratories (VL) are another way to develop online laboratories. Simulation software has long been used for teaching. The real integration of virtual laboratories, with a 3D environment, is more recent.

Some examples are presented here. In [4] a winder for textile engineering is simulated using Virtools, [5] reproduces microscopy imaging of material. An online laboratory for biotechnology is presented in [6] and comprises several different scenarios. A laboratory for process control experiments has been developed with three access modes (hands-on, virtual and remote) [7]. To find A review on virtual laboratories in science has been edited [8].

Nevertheless, the use of information technology for education leads mostly to formatted activities. The interactions between the student and the learning medium are reduced to predefined scenarios, which are few in number.

1.3. Project and objectives

This paper presents a virtual laboratory platform developed at the University of Bordeaux. This project is in a definition and experimental phase and is not yet complete. The target audience is students in bachelor's and master's science and technology degrees with most of the students concerned being on bachelor's degree programs. The virtual laboratory should enhance the offer of online educational materials and help and motivate the younger students in their discovery of science and technology at the university.

In a second phase, the platform is intended to be open to high schools and lifelong learning. If the project is to be sustainable, it requires extensive use of the platform by users and ownership by teachers. The founding principles of the platform are presented below.

1.3.1. 3D environment

Considering the extensive use of CAD-CAM-CAE systems by the students, the 3D games they play, the progress of virtual reality, the 3D problems encountered in dimensional and geometrical metrology, the project is firmly committed to 3D, even if, from a pedagogical point of view, 2D is often sufficient. Nevertheless, a 2D environment is still considered for some exercises, to simplify the user interface.

3D Virtual Lab content is the same as real lab content. A set of observation and measurement instruments must be available as well as "bodies" (mechanical parts, optical components, electronic components, chemical equipment, etc.) and "substances" (materials, acids, reactives, etc.). The student will interact in 3D with these objects and substances through actions: moving, lifting, opening, closing, pouring, etc.

1.3.2. Open experimental procedure

Virtual experiments will leave a degree of initiative to the student, who must have some freedom of action. The manipulations should not be imposed. Depending on his scientific and technical skill, the student must conduct experimental procedures as he wishes, with the tools and objects provided by the teacher. He should not be restricted to a linear storyline, predefined and formatted.

The teacher, for his part, creates a virtual experiment exercise proposing targets and educational scenarios on Moodle, and prepares the virtual 3D environment, selecting the tools (instruments for measuring, observing, handling, etc.), and the objects (solid, liquid, gas, that can be measured, observed, manipulated) available in the student interface.

1.3.3. Disciplinary openness

The virtual lab aims to host all kinds of experimental work, in different areas of physics (mechanics, electronics, optics, etc.) but also in other sectors such as chemistry, and perhaps biology.

Using a modular design from the beginning of the project should make it easy to add items, tools, behaviors, etc., while keeping the same platform (user interface, connection to the LMS, student session management, etc.). Obviously, for each discipline specific modules will need to be developed.

1.3.4. Consideration of uncertainties

In most of the existing VLs [4-7], the variability of parameters and measurement of uncertainties are not usually considered. Yet this plays a key part in the analysis of the experimental results provided by practical exercises.

One of the main pedagogical innovations of the project is based on considering the variability of the input parameters and uncertainties of the measuring instruments.

1.3.5. Integration into an LMS

This new "virtual laboratory" is to be integrated into an LMS (Learning Management System), Moodle initially, and can be interfaced with existing educational tools.

The LMS tools are used to build training courses including a virtual laboratory with an adequate sequencing of educational activities. The scenario of the virtual experiment is not part of the virtual laboratory, it is defined in Moodle. The virtual laboratory is seen as a simulation tool.

The virtual experiment should become an LMS activity in itself, like any other educational activity, but using a 3D environment.

1.3.6. WEB application

As it is to be used by every student, everywhere, independently of the operating system used (Windows, iOS, Android, etc.), the choice of application structure fell on a web application.