

A SCORM Based Package Model for WebLabs

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Abstract—Web Laboratories (WebLabs) are essential resources for engineering education. Within this type of laboratory, a new Sharable Content Object Reference Model (SCORM) package design model is shown in this work. The proposed model is based on a set of resources that form a complete educational structure; taking into account the sequencing and navigation among the elements that compose it. In addition, it can be uploaded to a Learning Management System (LMS), offering to the students an effective tool to work with web labs. The package is structured in 4 sections or pages: Introduction, Theory, Virtual/Remote Laboratory (VRL) and Assessment; where the last performs an automated verification of the work done by the learner. In this way, one of the advantage of this methodology is that the instant results of the assessments, performed by the SCORM package, is stored in the inner LMS. Some WebLabs performing this methodology are being developed in the University of Jaén. In this work, an example is developed: “Modelling of Dynamic System: DC Motor”. This WebLab is used in the Industrial Automation course that is included in several Industrial Engineering degrees.

Keywords— *Virtual Remote Laboratories; SCORM; LMS; dynamic system modelling; automatic control.*

I. INTRODUCTION

In the university technical programs of engineering and applied sciences degrees, the laboratory work is essential for the correct training of the students. There are several ways to perform laboratories in education: hands-on labs, virtual labs or remote labs [1][2][3]. Depending on the experience one wants to repeat, there are some implementations that are considered more suitable than others. When experience is offered in virtual or remote way, Internet has been used, and more specifically, the use of the Web service [4].

The main tool used in higher education over the Internet is the LMS [5]. LMSs, which have evolved greatly from its origins, are not just a repository of educational content. For instance, the more advanced LMSs also perform other functions among which we would highlight the following:

- They provide tools for learner-tutor communication.
- The integration of services and applications, that facilitate the creation of content in different formats.
- The integration of facilities, that help the assessment and the tracking of the student learning progress.

Until a relatively short time ago, there was a gap between the use of VRL and LMS; however, in recent years, there have been a number of proposals aimed at reducing this gap [5]. Many initiatives have developed ad-hoc solutions [6], others have researched the federation protocols [7] or have used, as a container of VRL, SCORM, which is the standard for e-learning content more widespread among the LMSs [8]. Finally, there is also an example where data exchange occurs with the LMS [9].

This paper works on the use of SCORM for the integration of VRL as embedded objects capable of exchanging information with the LMS. SCORM is a set of technical standards for e-learning products designed to obtain reusable, durable, interoperable and accessible content in the LMS. These specifications were used to develop the model proposed in this work. SCORM allow define encapsulation, launching and exchange of data between VRL and LMS by defining three sub-specifications, a) Content Aggregation Model (CAM), b) Sequencing and Navigation (SN) and c) Run-Time Environment (RTE) [10]. On the basis of the teaching proposals for remote laboratories developed in [11], in this paper, a content structure pedagogical model, based on a SCORM that includes an embedded VRL, is proposed. Thereby the VRL is not treated like an isolated element; it is fully integrated into the student learning experience as proposed in [12]. In the proposed model two types of learning resources, that LMS can launch, are developed: assets and Shared Content Objects (SCO). An asset is a resource consisting of digital media such as text and images. It can be loaded through a Web browser but it does not communicate with the LMS. A SCO is a collection of one or more assets that should communicate with the LMS using the Run-Time Environment.

The rest of the paper is organized as follows. In the next section, desirable characteristics in the design of VRL are presented; in section III, the proposed model is described, justifying its format; in section IV, an example of virtual laboratory using the proposed model is presented and, finally, in Section 5, the conclusions and future lines are given.

II. VRL DESIGN BASED ON SCORM

The main objective to be met by laboratories is to provide to students experiments which can link theory to the real world [13]. Thus, it helps to understand the theoretical and skills of practical use of the systems are acquired. However,

for a VRL to be effective and that can meet this requirement, it must take into account the following factors:

Working Environment.

Normally, WebLabs are hosted along with the other contents of a course in a LMS. The WebLab must be consistent with them and it must be supported in previous contents which must have been treated by learners. These contents can be theory modules, tests, exercises or any combination thereof. In addition, the WebLab can serve as a previous content to another laboratory. The proposed model takes into account that a WebLab is not an isolated element and therefore it has its place among the course content to complement them. WebLabs, and other resources of the working environment, must be referenced to each other and must also be presented to the student as a whole.

VRL

There are many desirable properties in their design. The interaction must be credible. By this we mean that, when it comes to simulations of physical systems, it is necessary to allow a similar interaction as the real system does. It's desirable to perform a customization of the VRL functioning. This can be easily carried out using in the WebLab the user identification that is performed by the LMS and the VRL-LMS communication capability provided by SCORM. In addition, the user interface must meet functional aspects that facilitate its use: suitable design (simple and intuitive) and instant help.

(Auto)Assessment

The interactions are performed through software (it's the medium of access in the case of RL), so it's possible to perform the assessment tracking and the assessment. The results can be communicated to the LMS through the SCORM RTE. To do this, it's required the use of the Javascript Application Program Interface (API), provided by the LMS. This can be quite complicated if you do not use software tools to facilitate this task as the scormRTE JAVA package [14], used in the example shown in this paper. Automatic assessment also provides benefits for the tutors who must manage their teaching in the LMS.

Web Design

SCORM features provide total flexibility in appearance to the content designer. It is an aspect that should not be forgotten and that we must take care in order to obtain an intuitive, clear and attractive content for the learner [15]. In our model we have created a functional interface with simple visual design that facilitates and simplifies its use by learners. Web design is reduced to the essential elements that are necessary for the implementation of the laboratory. The chosen typeface is simple and clean, and the colours are coordinated and balanced. Besides a good organization and explanation of the contents, the items explained here are basic pillars for a quality WebLab.

SCORM Design

SCORM defines encapsulation, navigation and communication for a given content structure. It is recommended that content creators and teachers choose and maintain an agreed structure that, once known by students, will be used at different WebLabs to facilitate their work. They also have to define and reach agreement on: a) Navigation between SCORM objects and b) Communication between each SCO and the LMS. Section III shows, in more detail, the SCORM design applied to the proposal model.

Productivity

Productivity is a sought objective in all works. WebLabs is considered productive if, meeting these design requirements, learners can get the most out to achieve the main objective for which it was designed: the acquisition of the corresponding skills.

III. PROPOSED WEBLAB MODEL

The model is a pedagogical context developed following principles of web usability and design focused on the needs of end users: tutors and students. Sequencing/Navigation and structure of the proposed WebLab model can be seen in the flow diagram of the example included in this work (Fig.1).

It consists of four web pages, each of which corresponds to a SCO:

SCO1. Introduction

It provides an overview of the WebLab placing it within the degree studies. It provides also links to the basic theoretical contents of the course. In addition, it presents a graph and description of the WebLab (structure and navigation) that helps students to better understand it. This SCO performs a basic connection to the LMS to inform about the learner who visit it (and consequently pass it).

SCO2. Lab Theory

It provides basic theoretical information for better understanding of the experiments to be performed in the VRL. This information should extend the theoretical lesson of the course that is enriching the VRL. It particularizes the more general ideas given in the theoretical lesson of the course to the specific case of VRL.

After showing this information, it presents the initial test that students must overcome to demonstrate that they have successfully assimilated the information received and that they are ready to work with the VRL that is found in SCO3. If the initial test is not passed the system will show again page 1 of WebLab (SCO1). If passed, it will store in the LMS the completion status as "passed" and the score of the learner.

SCO3. VRL

It contains the guide notes of the practices that the learner must perform in the VRL. They must be specific instructions, unambiguously, describing clearly the work to be performed by learners. It also includes the embedded VRL as an Applet that must have been programmed so that may track practices

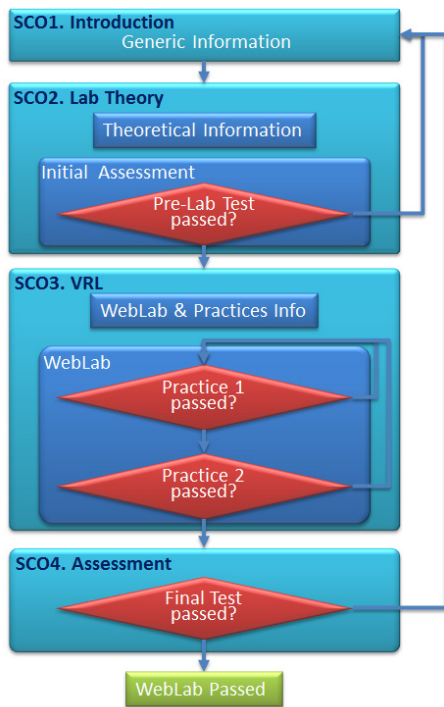


Fig.1 SCORM Structure and Navigation of the example WebLab.

and perform their assessment. If the learner does not pass the automatic assessment, the applet will be reset to its initial state, forcing the learner to begin the practices again from the beginning. Although Fig.1 shows a case of two practices, the proposed model does not determine the number of practices to include. This ultimately depends on the opinion of the content creator and the designer. The applet can use software tools [14] to facilitate communication with the LMS for, among other exchanges, store the completion state of student and the score.

SCO4. Assessment

It presents the final test which the learner must demonstrate that has acquired the knowledge and skill that is studied in WebLab. If passed, the learner will have successfully completed WebLab and the SCORM package will automatically close. Before closing the VRL, it communicates with the LMS to store the score and the state "passed" of the involved learner. In case of not overcome the final test, the LMS will return to the SCO1 and the learner must begin again the whole WebLab.

Title	Status	Time	Score
SCO1-Introduction	passed	20 Seconds	
SCO2-Theory	passed	26 Seconds	24
SCO3-VRL	passed	1 Minute	20
SCO4-Assessment	passed	39 Seconds	28

Fig.2 Screen capture of the ILIAS LMS Tracking Data View.

As described above, each of the pages does a connection with the LMS, so it is possible to customize its operation. Besides, SCO2, SCO3 and SCO4 communicate the result of their interactions performed by the student in each of them (completion states and scores). The format in which LMS offers this information to the tutors depends on the LMS and its SCORM implementation, e. g., Fig. 2 shows the information provided by ILIAS, the institutional LMS of the University of Jaen (UJA).

The following WebLabs have been developed using the model proposed in this paper: "Modelling of Dynamic System: DC Motor", "Dynamic System PID Control: DC Motor", "Modelling of Dynamic System: Heat Exchanger" y "PID Control of a Heat Exchanger System" (in English and Spanish language), introducing now the first one.

IV. WEBLAB EXAMPLE: "MODELLING OF DYNAMIC SYSTEM: DC MOTOR"

Below is described an example of the developed WebLab: "Modelling of Dynamic System: DC Motor". It is a WebLab which includes a VL about the dynamic identification of a DC motor. The VL has basically the same characteristics that a DC motor that students have to use in the Automation laboratory in future practices. Thus, working with this WebLab, the students can understand the operation of the real system before dealing with it.

SCO1. Introduction

Among others, generic information data are shown to place the WebLab from the educational point of view, e.g. it indicates that the WebLab is used in the "Industrial Automation" subject that is included in several Industrial Engineering degrees of the UJA and that there are links to related theory lessons that are uploaded in the same LMS. It also includes a description of the structure of WebLab and how to overcome it.

SCO2. Lab Theory.

It shows theoretical content to be studied before working on the VRL: *a) Introduction*: it includes the main goal of the WebLab and an image of a DC motor. *b) Dynamic model*: it includes a DC motor model scheme, a list of the variables and the physical parameters of the model, the system equations and the dynamics equations in time domain and Laplace domain. *c) First-order Dynamic Model*: it includes a scheme of a first-order system particularized for the DC motor, it defines the constants that define a first-order system (static gain and time constant), and how they are calculated theoretically from the graph of the output of the system.

It then presents the initial test. This test assesses the student's ability to assimilate the specific theoretical concepts given. The initial test consists of a series of multiple choice questions (and only answer) that students must overcome (at least 50%) to continue to the next page.

SCO3. VRL.

It contains the guide notes of the two practices to be performed by students:

Practice 1. Testing the DC Motor simulator.

It is designed for the student to acquire confidence when handling the simulator. The learners test the simulator, select different input signals, check the outputs produced (graphics) and perform measures by setting the coordinates axes. When the mouse pointer is located over an item of the interface for a second (approx.) appears a pop-up window where help about the item is shown.

Practice 2. K and T parameters identification.

It guides, step by step, the learner to calculate the K and T constants of the DC motor first-order model following the instructions of the SCO2. The operation of the simulator is customized for each student: the system modelling is dependent on the user identification.

The VL (Fig.3) is a JAVA Applet created with Easy Java Simulations (EJS) [16] and scormRTE JAVA package [14] to facilitate the VL-LMS communication. It tracks the work of the learner. When the learner passes the practices, the VL store the completion status ("passed") and the score obtained.

SCO4. Assessment.

It presents the final test that assesses the learner's knowledge. It consists of a series of multiple choice questions (and only answer) that students must overcome (at least 50%) to complete successfully the WebLab.

A free access copy of this example is available in the LMS of the UJA, in the same URL there is a learning module with instructions about executing JAVA Applets in a browser: http://dv.ujaen.es/docencia/goto_docencia_fold_514733.html

V. CONCLUSIONS AND FUTURE ACTIONS

A WebLab model, based on SCORM and which is being used in the course of Industrial Automation, is presented. This course is included in the Engineering Degrees on Industrial, Mechanical, Electrical and Electronic of the UJA. The proposed model is based on SCORM, making easy to export and use it in all SCORM compatible LMSs. It has been designed taken into account pedagogical principles of teaching quality and follows principles of Web usability and design focuses on the needs of the end users.

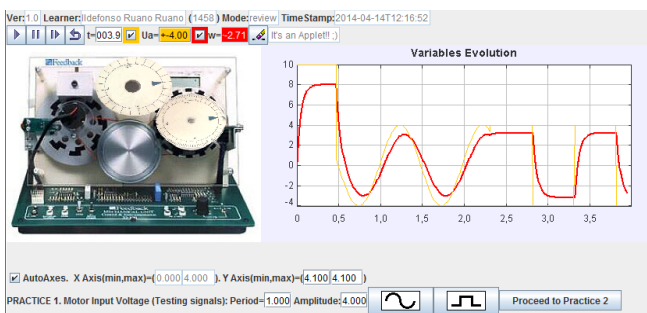


Fig.3 Screen capture of the VL.

On the basis of this proposal, several future actions are defined. First, analysing the usage data and opinions of students who will work with WebLabs that follow this model. Second, the possibility of performing remote laboratory sessions of the same examples and compare the results.

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