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Packing and Reusing Virtual Web Laboratories as Sharable Content Object in wide range of educational Fields

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Abstract— One of the key issues in the education field is the acquisition of skills. This practical knowledge was usually acquired through traditional labs or standalone simulation programs. The World Wide Web and the advance in web programming language have allowed teachers to create online learning applications, such as virtual web laboratories which can be displayed by Web browser, at any time and everywhere. Currently, a large amount of virtual Web labs can be found in the World Wide Web, and these are able to cover a wide range of educational fields such as physic, chemistry, electronic, medicine, mathematics and languages. This paper describes the process of searching of these laboratories and their packing in Sharable Content Object, following the e-learning standard called SCORM.

Keywords—*Sharable Content Object; Learning Objects; Learning Management systems; Virtual Web Laboratories.*

I. INTRODUCTION

Currently, it is very common to see students working with learning tools which are run for PCs, tablets or mobiles. But, until 80s, students acquired knowledge and skills through traditional resources and activities such as books, cassettes, videocassettes, face to face classrooms and traditional laboratories.

These learning resources and activities are being replaces or complemented with e-learning resources and applications, for instance:

- Books are being replaced by electronic files (Webpages, PDFs or epub).
- Cassettes or videocassettes have been replaced by podcasts and electronic video.
- Face to face classrooms are not replaced fully, but they are being complemented with learning applications, such as learning management systems, which allow teacher to create learning scenarios. According Klebl [1] a learning scenario is a social setting dedicated to learning, education or training. It is a process of interaction between people in a specific learning

situation using resources for learning within a designed environment.

- As the Face to face classrooms, Traditional Laboratories are being complemented or replace by learning application called virtual and remote Labs.
 - Virtual Labs are simulation programs which allow student to carry out experiment at anytime and anyplace.
 - Remote Labs are programs which allow student to carry out experiment with real instrumentation at anytime and anyplace.

Both electronic files, learning management systems, virtual and remote Labs be uploaded to Internet and displayed, depending on the format, over different devices, such as PC, electronic readers, tablets, or mobiles. Therefore, currently it is possible to find a great number of learning resources and applications. Each one are developed in different formats and programming languages. In the case of e-learning resources, many groups are working in the developments of e-learning standards which allow teachers to search and reuse these learning resources, such as:

- IEEE Learning Object Metadata (IEEE LOM) [2], which enables learners or instructors to search, evaluate, acquire, and use learning resources or objects across any technology supported learning systems. To do this, LOM defines the structure of a metadata instance for a learning object. This conceptual schema specifies the data elements. In the schema, data elements are grouped into nine categories: General, Cycle-Life, Meta-Metadata, Technical, Educational, Rights, Relation, Annotation and Classification category.
- IMS Content Packaging (IMS-CP) specification describes data structures that can be used to exchange data between systems that wish to import, export, aggregate, and disaggregate packages of content [3]. This structure is called package interchange file (PIF)

and it stores a set of items (images, texts, etc.), and references to items from other PIFs in an organized way.

- Sharable Content Object Reference Model (SCORM) is a collection and harmonization of specifications and standards that defines the interrelationship of content objects, data models and protocols, such that objects are sharable across systems that conform to the same model [4][5].
- The IMS Question & Test Interoperability (IMS-QTI) specification describes a data model for the representation of question (assessmentItem) and test (assessment) data and their corresponding results reports. Therefore, the specification enables the exchange of this item, assessment and results data, between authoring tools, item banks, learning systems and assessment delivery systems [6].

These and other e-learning standards have been developed to make easier the searching and reusing in learning environments, such as learning management system (LMS) or Courseware.

This paper describes the process of collecting different virtual Labs which are over Internet, packing them in Shareable Learning Object (following the e-learning standard called SCORM) and their integration with learning management system. These steps make easier the creation of learning scenarios in different LMSs without having to do many changes.

II. SCORM

As it was mentioned, SCORM is a collection and harmonization of specifications and standards that defines the interrelationship of content objects, data models and protocols. It is divided into three main sections:

1. Content Aggregation model.
2. Run-Time Environment.
3. Sequencing and Navigation.

A. Content Aggregation Model

It describes the components used in a learning experience, how to package those components for exchange from system to system, how to describe those components to enable search and discovery and how to define sequencing information for the components (Fig. 1). These components are:

- Assets are an electronic representation of media, such as text, images, sound, assessment objects or any other piece of data that can be rendered by a Web client and presented to a learner.
- A SCO is a collection of one or more assets. The only difference between a SCO and an asset is that the SCO communicates with an LMS using the Institute for Electrical and Electronics Engineers (IEEE) ECMAScript.

- A learning activity may provide a learning resource (SCO or asset) to the learner or it may be composed of several sub-activities.
- A content organization is a representation or map that defines the intended use of the content through structured units of instruction (activities).
- Content aggregation can be used to describe the action or process of composing a set of functionally related content objects so that the set can be applied in a learning experience.

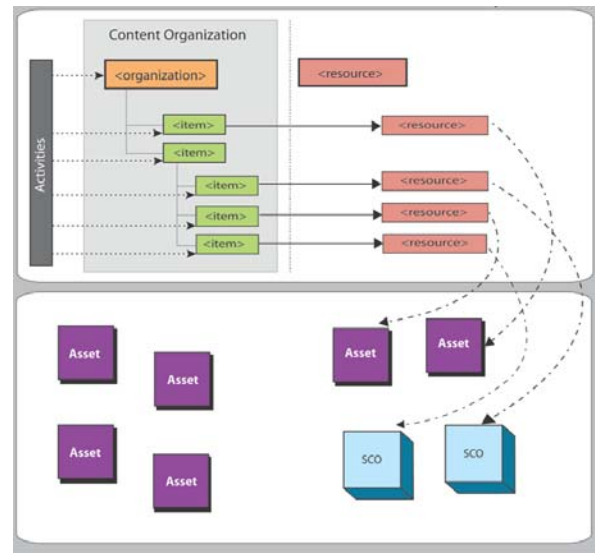


Fig. 1. Content aggregation model [4].

B. Run-Time Environment

It describes the learning management system (LMS) requirements in managing the run-time environment (i.e., content launch process, standardized communication between content and LMSs and standardized data model elements used for passing information relevant to the learner's experience with the content). In the figure 2 is shown how the data model exchange information with the LMS.

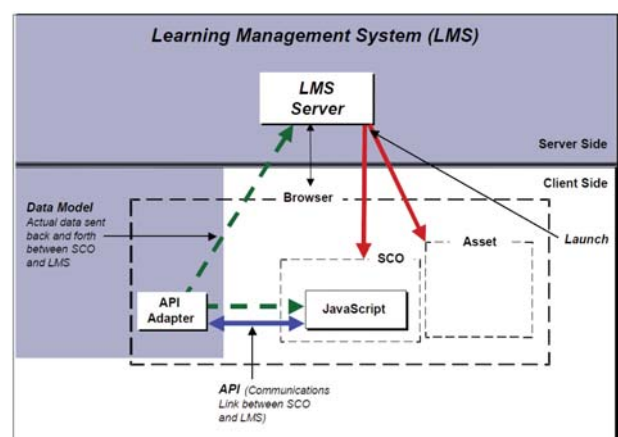


Fig. 2. Run-Time enviroment [4].

C. Sequencing and Navigation

It covers the essential learning management system (LMS) responsibilities for sequencing content objects (Sharable Content Objects [SCOs] or assets) during run-time and allowing those SCOs to indicate navigation requests. Therefore, it describes in detail how sequencing behaviors are applied to track learner progress.

III. PACKING VIRTUAL LABS IN SHAREABLE CONTENT OBJECTS WITH SCORM

Before describing this process, is important to describe in more detail what a Virtual Web Lab is. As it was mentioned a virtual Lab are simulation programs which allow carrying out experiment at any time and any place. The programs which are developed for the World Wide Web and displayed by a Web browser are called Virtual Web Labs (Fig 3).

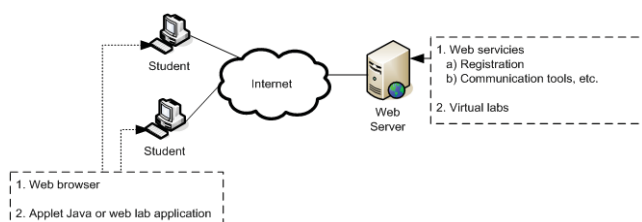


Fig. 3. Virtual Web Lab.

Therefore, Virtual Web Labs are developed in different technologies such as Java Script, Java Applets, Flash Applets or Active X and can be embedded in a HTML page and included as an asset of SCORM package.

This section describes the process of searching and packing of virtual web Labs in a SCORM package.

A. Searching Virtual Web Labs

Currently it is possible to find a great number of them over Internet and they cover a wide range of educational fields, such as: chemistry, mathematic, biology and physic. Therefore, many virtual web Labs are searched by internet. The results of this searching were 28 virtual web Labs, divided into:

- Six Web Labs of physic:

1. <http://www.enciga.org/taylor/lv.htm>
2. <http://www.phy.ntnu.edu.tw/java/index.html>
3. <http://www.sc.ehu.es/sbweb/fisica/>
4. <http://www.walter-fendt.de/ph14s/>
5. <http://perso.wanadoo.es/cpalacio/30lecciones.htm>
6. <http://www.pidlab.com/en/home>

These Labs allow students to carry out online experiment about electromagnetic, light-optic, mechanics and waves.

- Five Web Labs of Chemistry

7. <http://www.chemcollective.org/applets/vlab.php>

8. <http://www.chem.ox.ac.uk/vrchemistry/labintro/newdefault.html>
9. <http://chemistry.dortikun.net/>
10. <http://www.dartmouth.edu/~chemlab/> (Dartmouth College)
11. <http://www.chm.davidson.edu/vce/Equilibria/index.html>

These Labs allow students to carry out online experiment about complex ions in aqueous solution, Interactive Organic Mechanism, Named Organic Mechanism and Organo-transition metal chemistry.

- Seven Web Labs of Biology

12. <http://www.hhmi.org/biointeractive/vlabs>
13. <http://biomodel.uah.es/lab/inicio.htm>
14. <http://web.mit.edu/star/genetics/>
15. <http://www2.edc.org/weblabs/WebLabDirectory1.html>
16. <http://phet.colorado.edu/en/simulations/category/biology>
17. http://www.edu365.cat/aulanet/comsoc/Lab_bio/bio_simula.htm
18. <http://virtualurchin.stanford.edu/index.html>

These Labs allow students to carry out online experiment about cardiology, immunology, bacterial identification and genetic.

- Six Web Labs of Mathematic

19. <http://www.walter-fendt.de>
20. <http://palmera.pntic.mec.es/~jcuadr2/laboratoriosd/>
21. <http://onlinestatbook.com/rvls.html>
22. <http://www.math.uah.edu/stat/>
23. <http://virtualab.in/blog/>
24. <http://ccl.northwestern.edu/netlogo/models/index.cgi>

These Labs allow students to carry out online experiment about Geometric Models, Bernoulli Trials, Finite Sampling Models, Games of Chance and Markov Chains.

- Two Web Labs of Electronic to understand basic concepts about electronic.

25. <http://tec.upc.es/el/moreno/index2.html>
26. http://meteo.ieec.uned.es/www_Usumeteog/

- Two Web Labs of idioms to learn a foreign language

27. <http://lvi.educarex.es/>
28. <http://www.englishlab.ucn.cl/>

B. Packing Virtual Web Labs in Shareable Content Objects

Once these Virtual Web Labs are found, the step of packing them in a Shareable Content Objects (SCOs) is carried out. To do this, there are several SCORM editors which make easier the creation of SCOs. The most well known is Reload [7].

To describe this section deeper, an example of one of the listed virtual web Lab is going to be explained:

1. Once the reload editor is downloaded in the PC, teachers can open it, doing double click in the executable file. A graphic interface is displayed with a menu of options.
2. Teacher select the option edit→new→ Adl SCORM package (Fig 4).
3. Once it created the empty SCORM package, the editor ask for a directory where the files or learning resources, which are going to be added to the package (Lab, manuals, etc.), are stored and shows the structure of package SCORM (Fig. 1 and 5). The files and resources are added and organized through drag and drop. The Virtual Web Lab is embedded in a HTML page. In the figure 5 the HTML page Laboratorio.html contains the web Labs (adding the URL as a reference or embedding the applet of active X)

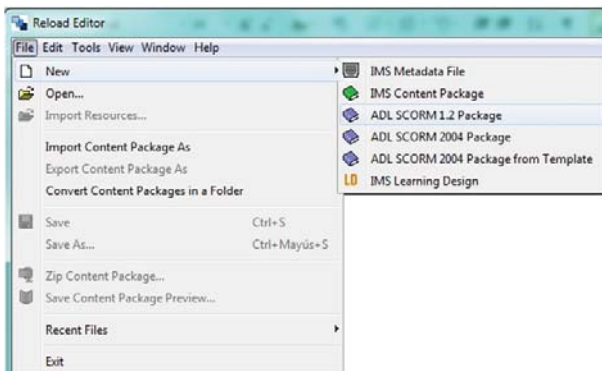


Fig. 4. Creating a empty SCORM package.

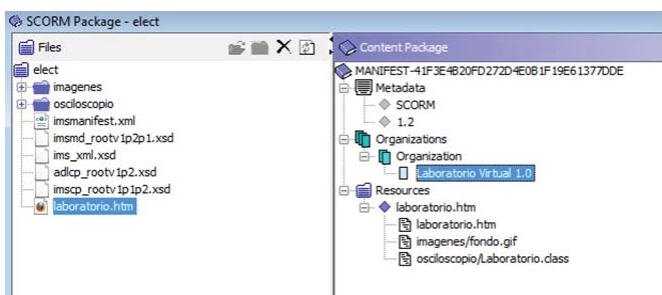


Fig. 5. Creating a SCORM package with several HTML pages.

4. Once all the resources have been included, Teachers save the package in a zip file and see a preview of the package (Fig. 6), using the editor.

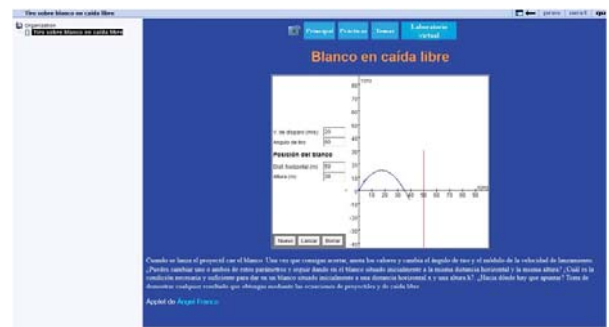


Fig. 6. Preview of packed virtual Web Lab in a SCORM Package.

IV. ADDING THE SCORM PACKAGE IN A LEARNING MANAGEMENT SYSTEM

An LMS is a framework that delivers and manages instructional content, identifies and assesses individual and organizational learning or training goals, tracks the progress towards meeting those goals and collects and presents data for supervising the learning process of an organization as a whole [8-10]. These can be classified as:

- Proprietary LMS, such as Blackboard [11].
- Open Source LMS, such as Moodle [12], dotLRN [13] or Sakai [14].

While, the proprietary LMSs only allow determined programmers to know its source code, the open LMSs allow some programmers can know its source code, modify and adapt it to the needs of the university or institution for their work.

The vast majority of LMSs provide educational tools, such as:

- Administration. It must be able to manage user registrations, roles, assign tutors, user payments, etc
- Synchronous and asynchronous Communication Tools. It must allow collaborative work. So that they can share information, opinions and experiences.
- Evaluation. The tutors and teachers must be able to evaluate the student's progress. Also the students can do test where they can see their progress. To do it, The LMS provide a set of assessments tools and in some cases these tools fulfill with e-learning standards as IMS QTI (Question and Test Interoperability).
- Tracking user. A set of tools which provide information about user activity and the results of these activities.
- Content packing. It organizes the content in a hierarchical structure and sets up a mechanism to swap content between different learning management systems. To do it, it's usually used the specification IMS content packaging or the specification SCORM (Shareable Courseware Object Reference Model).

Therefore, The SCORM package which has been created in the previous section can be added along with assessments, chats, forums, etc. without having to program anything (Fig. 7).



Fig. 7. Adding a SCORM package in a Moodle course and wrapping it with e-learning Tools, such as Forum, Chat.

V. DISCUSSION

This article is focused on the idea of using Learning objects and a well-known e-learning standard called SCORM to reuse Virtual Web Laboratories. The adaptations of Web pages, which contain virtual Web Labs, to SCOs provide a set of advantages.

- The Virtual Web Labs are in a SCORM structure and around it, other web pages, videos, audio, applets are packed to provide a whole learning pack. Also it is organized following a sequence of navigation.
- Each SCORM package is described by a set of metadata which make easier the searching of Labs. For instance, it can be stored in a content management system and deployed in a LMS.
- The SCORM package can be modified with editors and it is not necessary to know about programming.
- The SCORM package can be added in a different LMS course (independently if it is Sakai, Moodle or Blackboard) and can be “wrapped” with e-learning tools such as authentication, forums, chats, assessments and file storage without programming anything.

But, this process also has a set of disadvantages, such as:

- Version problems. Not only, there is a version of one standard, For instance SCORM have several versions, such as v1.2 or v2004. These provide different features and API. So, if a teacher is working in packing a set of statics resources, then he should check the e-learning system where the content package is going to be installed.
- Standards, such as SCORM or IMS-CC, pack text, images, or even applets. Therefore, they are packing static resources. But, new e-learning resources, such as remote Labs are dynamic application which cannot pack in a zip file. To solve this, several new initiatives are emerging, such as:
 1. SCORM next generation. This project adds to SCORM a Web Service Runtime Communication Profile Standard (based on a Web Service binding of the IEEE 1484.11.2 functionality and on IEEE

1484.11.3) to exchange data between SCORM package and LMS [15].

2. Common Cartridge & Learning Tools Interoperability Alliance. It is the merging of two e-learning Standards:
 - a. IMS Common Cartridge defines a new package interchange format for learning content, able to run on any compliant LMS platform.
 - b. IMS Learning Tools Interoperability (LTI) v1.0 provides a single framework or standard way of integrating rich learning applications (in LTI called Tools) with platforms like learning management systems, portals, or other systems from which applications can be launched, called Tool Consumers [16].
3. Widgets. According to W3C World Wide Web Consortium (W3C), widgets are client-side applications that are authored using Web standards such as HTML and packaged for distribution. They are typically downloaded and installed on a client machine or device where they run as stand-alone applications, but they can also be embedded into Web pages and run in a Web browser. These can create complex applications that pull data from multiple sources to be “mashed-up” and presented to a user in some interesting and useful way (<http://www.w3.org/TR/widgets/>). These widgets can be combined to create online learning scenarios and activities which can be displayed in different devices, such as smart phones, tables, web browser and PCs.

To sum up, new initiatives, focused on reusing e-learning resources over Internet, are emerging. But, until these can be used, e-learning standards, such as SCORM, are good solutions to create learning scenarios in learning management systems

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