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THE INTEGRATION OF AN INSTITUTIONAL REPOSITORY AND A LEARNING MANAGEMENT SYSTEM: A CASE STUDY

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Abstract

The advantages and technical challenges concerning the integration of functions of institutional repository and learning management system are presented and discussed, based on a concrete example of the Maxwell System in Pontifical Catholic University of Rio de Janeiro (PUC-Rio).

Keywords: Institutional Repositories, Learning Management Systems.

1 INTRODUCTION

ICT – Information and CommunicationTechnology – has been under a very fast evolution in the last decades. New tools are continuously made available while offering a wide range of possibilties to support, enhance and extend the learning process.

Pontifícia Universidade Católica do Rio de Janeiro (PUC-Rio) is a university in Rio de Janeiro, Brazil. It has had many activities with focus on Engineering Education, with ICT being employed since 1995. As expected, the use of ICT has undergone many transformations since then, and three factors can be accounted for: (1) the evolution of ICT; (2) the international scenario where instituions introduced innovations in methodologies and in technologies; and (3) the maturation of the team at PUC-Rio.

Along with Engineering Education, an intense and extensive work has been under way devoted to digital resources management. The Maxwell System (https://www.maxwell.vrac.puc-rio.br), which is the platform of the case to be presented, began as a digital library of educational Resources in Eletrical Engineering back in 1995. As time went by, it grew and changed its mission and profile to become an IR – Institutional Repository – and an LMS – Learning Management System – both completely integrated. In both roles it incorporated a wide range of functionalities.

This paper addresses the study of the characteristics of such integrated platform and the results that have been achieved with this model. It is divided in 6 sections besides this introduction.

2 ICT IN ENGINEERING EDUCATION AT PUC-RIO

Some uses of ICT in education are solely based on software. Some software products come out of the shelf and can be used to solve problems in a stand-alone way or can be combined and/or transformed to generate digital learning contents.

Products for numerical computation can be separated in two large groups: (1) general purpose; and (2) application-specific. In both groups there are commercial products as well as free and open source solutions. Some examples of the first group are MATLAB®, Maple®, Scilab and GNU Octave; the first two are commercial and the others are free. If the second group is considered and electric circuits are the focus, four examples are CircuitLab®, Cadence®, LTSpice and Fritzing; the first two are commercial and the others are free. At PUC-Rio, Scilab has been used to implement learning materials with embedded simutations. There are 45 contents with 142 simulators; 32 are originals in Portuguese and 13 are English versions. Note that simulator codes are shared by originals and their respective versions. Fig. 1 shows one such materials.

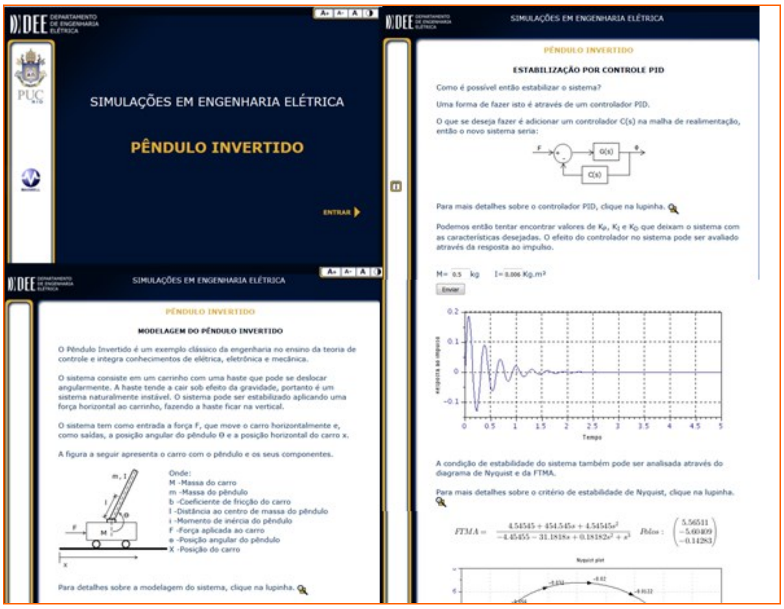

Figure 1. Screenshots of a content with simulators.

Other types of contents that are solely based on software are videos, animations, hypermedia objects, spread sheets and datasets with different types of data. Other courseware are based on html5, JavaScript, animated gifs and php. Currently, there are eight series of learning objects plus two course outlines that rely on this type of technology, adding to 181 objects.

A set of four interactive books (*Livros Interativos de Engenharia Elétrica*) is published too. They have over 700 exercises, each one with at least 3 sets of parameters that are randomly chosen every time an exercise is opened.

Software based learning contents are used in the blended learning (b-learning) courses at PUC-Rio. One example is discussed in [1]. Other uses of ICT integrate hardware/artifacts and software. Remote Labs, as defined in [2], belong to this type of use of ICT. PUC-Rio deployed VISIR – Virtual Instrument Systems in Reality, a Remote Lab for Electric and Electronic Circuits, and has used it since 2016. VISIR has been used by other institutions [3]. The introduction of VISIR required the management of various digital contents for the operation of the hardware as well as the theoretical and practical aspects of the experiments. Two other Remote Labs are under development at PUC-Rio.

PUC-Rio makes available OA contents through the aggregator of data and contents on the Maxwell System – Open Educational Resources @PUC-Rio (https://www.maxwell.vrac.puc-rio.br/OER/index.php). OER is the international acronym for Open Educational Resources.

3 SOME CHARACTERISTICS OF THE COLLECTION AND OF THE AUDIENCE

The collection offers digital contents that are expected to be read/studied by an audience. This section examines some characteristics of each and is of paramount importance to understand the integration.

3.1 Characteristics of the collection

The educational items of the collection can be grouped in three types:

- Inputs to the learning process – this group contains all learning contents that number over 1,300 when the exercises in the interactive books are included. Among them, approximately 180 are restricted.
- Outputs of the learning processes – this group contains works that students present as requirements to get their degrees: theses, dissertations, monographs and senior projects. The total number in this group is higher than 16,000.
- Scholarly communication – this group contains articles, technical reports, books, etc. The total number in this group is higher than 2,600.

The total number of contents that are related to the educational process is approximately 20,000. ETD – Electronic Theses and Dissertations, Senior Projects and Monographs come from different courses and graduate programs, and are in Humanities, Science & Technology and Social Sciences. Contents whose function is to support learning are more than 1,300 and are focused in Control & Automation and Electrical Engineering curricula. In this group the are contents that can be used in courses in different areas; one example is the Bode Plot that is used in Electric Circuits and Control Systems, but there are many more.

The three types have items in languages other than Portuguese (English, Spanish, French and German). Learning contents may have two versions – Portuguese and English.

Another type of digital files that will be presented in section 5 are the Assets defined in SCORM – Shareable Content Object Reference Model [4]. There also are technical contents related to the organization and management of the experiments performed using VISIR; this Remote Lab was integrated into the Maxwell System [5].

3.2 Characteristics of the audience

The Maxwell System is accessed by users from all over the world. Some examples of numbers of countries that accessed contents in 2018 are:

- OER – 91 countries
- ETD – 194 countries.
- *Atualidade Teológica* (a journal on Theology) – 110 countries

The examples are of the three types presented in section 3.1. Contents in OER and the journal are 100% OA; ETDs are approximately 80% in OA. The numbers indicate that there is a broad audience outside PUC-Rio and outside Brazil. These numbers and many others could be collected due to the model used for the Maxwell System.

At the same time, there is PUC-Rio's own audience – the students of: (1) traditional courses that use the system to support activities; (2) b-learning courses; and (3) distance learning (e-learning) courses. Students using the Remote Lab can be in both traditional and b-learning courses. For all cases above, the objective is to have users finding the contents they need.

There is a third group of players whose needs must be considered – faculty who create courseware and want students to use it. Since developing courseware requires financial resources and time, besides knowledge and technical skills, it is very important that reuse and share are possible. Reuse and share have been a concern for quite some time. SCORM (Shareable Content Object Reference Model) is devoted to sharing contents. The terms reusable chuncks of instructional media, reusable instructional components, reusable digital resources, reusable learning objects (LO) were used as far back as 2000 [6]. In 2009, the expression Reusable Learning Object (RLO) was employed [7]. These concepts are important to understand the next sections.

There are two definitions that are important to mention because the have implications in the decisions that were made.

“For this standard, a **learning object** is defined as any entity – digital or non-digital – that may be used for learning, education, or training.” [8]

Learning Objects are represented by the acronym LO and LOM means Learning Object Metadata which is the IEEE Standard to describe LOs [8].

“**SCO**s are the smallest logical unit of information you can deliver to your learners via an LMS.” [4]

SCO is the acronym for Shareable Content Object in SCORM.

When the two definitions are examined it is clear that both refer to units or entities used for educational purposes. The big conceptual difference between LOs and SCOs is that LOs can be digital or non-digital whereas SCOs are to be delivered via an LMS, and therefore must be digital. There are other differences in terms of description and implementation.

In the scope of this work, LOs are considered, because all contents related to the Remote Lab, though digital, refer to a non-digital learning equipment. Some of them imply in actions of the Remote Lab [5].

4 INSTITUTIONAL REPOSITORIES AND LEARNING MANAGEMENT SYSTEMS

Institutional Repositories (IR) and Learning Management Systems (LMS) are two systems that are used in a large number of Institutions of Higher Education (IHE) all over the world. They are two different and separated platforms whose definitions follow.

“A university-based **institutional repository** is a set of services that a university offers to the members of its community for the management and dissemination of digital materials created by the institution and its community members. It is most essentially an organizational commitment to the stewardship of these digital materials, including long-term preservation where appropriate, as well as organization and access or distribution.” Clifford Lynch in [9].

The definition does not limit materials to scholarly communication or theses & dissertations. It is broad by stating “digital materials”. This means that digital courseware can be part of the collection of an IR.

“An **LMS** is comprehensive, integrated software that supports the development, delivery, assessment, and administration of courses in traditional face-to-face, blended, or online learning environments.” Wright, Lopes, Montgomerie, Reju and Schmoller in [10].

If IRs are under consideration, a visit to the Statistics page of OpenDOAR (http://v2.sherpa.ac.uk/view/repository_visualisations/1.html) indicates that the three most used products are DSpace, Eprints and Islandora. If LMSs are considered, there are many options both as products and as services. The most popular free and open platform is Moodle, which is a product. Most IRs share common features as most LMSs do too.

IRs offer tools to manage digital contents according to international standards and best practices. They include the Dublin Core Metadata Element Set (ISO15836) and the OAI-PMH – Open Archives Protocol for Metadata Harvesting. Persons are authors and contributors related to the digital contents, or the technical staff that uses and manages the platform.

LMSs offer different roles for persons as in the traditional school environment. At the same time, digital contents are not individually identified, they are included as parts of courses or classes.

5 THE INTEGRATED MODEL OF AN IR AND AN LMS AS A SINGLE PLATFORM

As previously pointed out, the Maxwell System of PUC-Rio started being deployed in 1995 as a digital library of courseware in Electrical Engineering. It hosted digital contents which were very simple due to ICT limitations. The functions were those of access control to contents. In the course of time, functions typical of LMSs started being added and as well as contents in other areas. Since ICT was in constant evolution, the quality of learning contents could be enhanced. In 1999, PUC-Rio registered the system with INPI – Instituto Nacional de Propriedade Industrial, the Brazilian Patent Office. At the same time, other types of digital contents started being published; the first ETDs in 2000. At that time, the system was an IR and an LMS.

In 2009, v4 was deployed with accessibility to the blind and the visually impaired [11]. In 2015, SciLab was integrated into the system so that users could access learning objects with simulations in a seamless way. Finally, in 2016 VISIR was integrated with the same objective.

We may now pose ourselves the question: why integrate funcionalities and products as a single platform?

5.1 The reason to integrate

Traditional brick and mortar universities and schools are integrated spaces where students, faculty and staff perform their tasks and are able to move from one environment to the other. They can leave a classroom and go to the library or walk down the hall to a lab class.

The reason to integrate different functions on a single platform was to emmulate the real world. This means that with a single identification a person can commute from one environment to another, as long as there is an authorization to do so.

5.2 Characteristics of the integration

In order to achieve the integration, some conditions were specified to ensure the funcionality fulfilled the specifications. The conditions were:

- Each person has only one identification that may be associated to different roles. One example is an undergraduate student who is the author of a Senior Project and then becomes a graduate student who authors a thesis – this person is uniquely identified and roles are characterized by additional information that comes from the University administrative systems. A person can have simultaneous different roles, for example, being a graduate student and a teaching assistant; each role has a different set of authorizations.
- Once identified on the system, an user can “walk” from one enviroment to another as long as entitled to do so – no additional identifications are required. Rights of access are defined by types and functions of users as well as academic activities to be performed. This includes the use of the Remote Lab that is also controlled by experiment scheduling.
- Database to include information of the University to identify courses, graduate programs, departments, etc. This assures integrity with other University systems.
- Users are controlled on the administrative subsystem of the Maxwell System and all academic rights and activities on the LMS subsystem.
- Digital contents contents are described and stored on the IR subsystem of the Maxwell System.
- Digital contents (courseware included) to be identified as individual items on the digital library (IR). The uses of contents in courses or classes are defined by tables on the database, so there is no replication of contents. Contents may be “text books” in one course and complementary references in others. This also allows contents to be in OA if authors decide so since they are not stored in course folders. This is similar to the traditional situation where teachers indicate text books and references from the library; at the same time, persons who are not students can access items of the library collections. An additional benefit is that no replication makes maintenance (updates, corrections) easier.
- Digital contents (courseware included) to be described according to national/international standards and best practices: DCMES (ISO15836) with 15 elements and its extended version DCMI Terms – Dublin Core Metadata Initiative Terms, with 75 elements. All metadata descriptions contain the language(s) of the content. Elements of “relation” of DCMI Terms are used to control language versions, editions, partitions, associated materials, etc. One example of partitions is the set of Simulator Objects, which can be partitioned in many exercises. One example of associated materials are datasets, multimedia files and computer codes. Partitions and associated materials are individually identified on the system

and relations are described according to their types; LOM elements (not the complete set) used to LOs; ETD-ms – an Interoperability Metadata Standard for Electronic Theses and Dissertations and MTD2-BR – Padrão Brasileiro de Metadados para Descrição de Teses e Dissertações used for ETDs.

- Digital educational contents are classified by subject. Currently, there are eight subjects as shown in fig. 2. This figure also indicates that the user may choose the language(s) of contents to browse. It is important to remark that a content may be classified in more than one subject area. One example is the LO on Rational Polynomial Functions that is classified in Control Systems, Electric Circuits, Mathematics and Signals & Systems. Currently 89.50% are classified in one subject area, 9.33% in two, 1% in three and 0.17% in four.

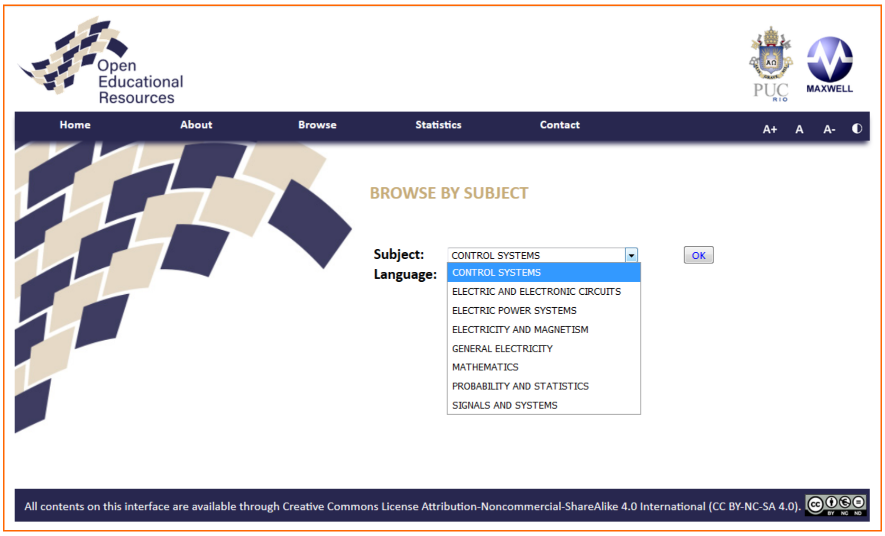

Figure 2. Browse by Subject option of aggregator OER @PUC-Rio.

6 RESULTS

The detailed description of contents has yielded many results and benefits in terms of usage, of access to contents and of obtaining managerial information. One important usage benefit is the management of Assets.

> “Assets are electronic representations of media, texts, images, sounds, HTML pages, assessment objects, and other pieces of data. They do not communicate with the LMS.” [4]

“Assets do not communicate with the LMS” but they can be managed by the IR of the integrated model, and this is what happens. LOs on the Maxwell System share a very high number of Assets – still images (schematics, block diagram graphics of functions, etc), texts (VISIR configuration files), moving images (videos, animations, etc) and code (SciLab). Many are shared among different LOs [12]. One example is the schematic representation of an RLC series circuit that is used in 25 LOs. SciLab code is also shared among simulator objects, specially because of the versions is Portuguese and English. The Asset collection has over 750 items and many more are waiting to be described since they had been created before the collection started in 2014. The descritpion of an Asset contains a Boolean variable that identifies the content as such. This collection has enhanced sharing and reuse and, therefore, saving time and money.

Another consequence of the integration is the possibility to implement aggregators that facilitate access to specific contents. So far, three aggregators are available:

- *Elétrica On-line* (https://www.maxwell.vrac.puc-rio.br/eletricaonline/) – launched in 2012. It aggregates all contents that are related to Control & Automation and Electrical Engineering, from ETDs to LOs; a library of links is also offered.
- Research Data (https://www.maxwell.vrac.puc-rio.br/ResearchData/index.php) – launched in 2018. It aggregates all datasets that are on the Maxwell System; all are in OA.
- Open Educational Resources @PUC-Rio (https://www.maxwell.vrac.puc-rio.br/OER/index.php) – launched in 2018. It aggregates all educational resources that are in OA on the Maxwell System.

A fourth aggregator is under development – ETD @PUC-Rio. It will be available next March. All aggregators offer many functions besides access to contents.

The last result to be mentioned is the large sets of statistics. Due to the detailed description of contents, 50 are available to all Internet users. The are divided in two types – production and accesses.

7 CONCLUSIONS

The integration of functions in one single platform requires more *a priori* work to manage contents and users. On the other hand, there is more flexibility of use, sharing and reuse of contents, information on content production and accesses, and the possibility to combine contents and functions with specific profiles to implement thematic aggregators.

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