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Creating a Collection of Assets in Electrical Engineering – a Project under Way

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Abstract

Information and Communication Technology tools provide both infrastructure and contents to enhance education. Engineering Education can benefit from ICT tools due to its nature – simulators, animations, online exercises can motivate and help the understanding of dynamic phenomena, for example. Development of good quality courseware is time consuming and requires financial resources. A team of different professional profiles is necessary to introduce good visual quality, develop interactions, etc. In order to lower costs and development time, it is important that contents be reused; this is one of the targets of content developers. A characteristic that contributes to the reuse of contents is their sizes or granularity. Another is the way they are managed to allow them to be searched, found and retrieved. When this happens, they are said to be structured. Besides the contents that are used to build lessons, modules, courses and curricula, there is a smaller digital component that belongs to contents – the asset. Though assets are not used directly in the learning process, they contribute through learning objects. Assets can be structured to be reused too. This work presents a project that created a collection of assets in Electrical Engineering – they are managed by a system that is at the same time an Institutional Repository and a Learning Management System.

Keywords: *asset, courseware, electrical engineering, ICT supported learning, institutional repository, learning management system.*

1. Introduction

This work addresses the convergence of different paths related to the use of ICT – Information and Communication Technology tools in various activities related to higher education in a Brazilian institution. The institution is the Pontifícia Universidade Católica do Rio de Janeiro (PUC-Rio) that has been involved with Engineering Education for almost two decades. The paths can be "walked" separately but, no doubt, yield better results when they converge. In order to understand each path, some background must be presented.

- Institutional Repository

In 2003, Lynch [1] introduced an expression that has been used worldwide since then – Institutional Repository (IR). He defined an IR as: **"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."** The definition is very broad since it aims at "digital materials created by the institution and its community members". One can think of ETD – Electronic Theses and Dissertations, journals, technical reports, articles, books and courseware. An IR can host, describe, give access and preserve digital resources that are inputs and/or outputs of the educational process. Courseware is of paramount importance as an input; it can also be an output since students can be active developers. This will be mentioned later in this work.

- Learning Management System

Wright et al. [2] defined a Learning Management System (LMS) as: **"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."** There are other ways of referring to such systems though this is the most used. It was the choice for this work.

- Learning Objects and Shareable Content Objects

Two expressions are very important in ICT supported learning. They are related to the definition of educational resources. The first is Learning Object (LO) and the second Shareable Content Object (SCO).

LO is defined in page 1 of the IEEE Standard for Learning Object Metadata [3] as: **"For this standard, a learning object is defined as any entity – digital or non-digital – that may be used for learning, education, or training."** LOs are items that can be combined for teaching and learning. Since LOs are not necessarily digital, the definition allows, for example, that laboratory equipment be identified, described and referred along with other educational resources. This is very important in Engineering Education since laboratory activities are a fundamental requirement in educating engineers. In the context of this work, LOs are digital entities.

"The Shareable Content Object Reference Model (SCORM) is a model that references and integrates a set of interrelated technical standards, specifications, and guidelines designed to meet high-level requirements for e-learning content and systems." [4] page 11-4. The SCORM defines SCO as: **"SCOs are the smallest logical unit of information you can deliver to your learners via an LMS."** [4] page 3-3.

Comparing the definitions of LOs and SCOs, it is easy to understand that they have:

- Differences: SCOs are to be delivered via LMSs while LOs can be non-digital, thus not to be exclusively delivered via LMSs. SCOs must be compliant to SCORM specifications that allow them to be delivered by any SCORM compliant LMS.
- Similarities: Both SCOs and LOs have educational purposes and are units/entities.

In 2000, Wiley [5] introduced the terms reusable chuncks of instructional media, reusable instructional components, reusable digital resources, reusable learning objects (LO). In 2009, Alsubaie [6] used the term Reusable Learning Objects (RLO). All these terms/definitions have much in common and, therefore, fuzzy boundaries. The subject of reusing and sharing educational resources has also been addressed in [7] and [8]. CMaps were used to help define the sizes of LOs aiming at their reuse in [9] and [10]. But all the definitions and worries focus the level of the resources that are managed by LMSs and that students and instructors recognize as learning topics. They can have different sizes and scopes, but they have learning objectives.

SCORM defines a lower level digital item – Asset. It is: **"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] page 3-2. Assets can be building blocks of LOs, RLOs and SCOs and can be redeployed, rearranged, repurposed, and reused in many different contents. Though assets do not communicate with LMSs, they can be stored, described, controlled and distributed by IRs. This work presents a model of managing assets in Electrical Engineering on an IR that is integrated with a LMS.

Section 2 addresses the context of the model and section 3 presents the solution that is under implementation and some partial results. Section 4 discusses the results and points to the next steps.

2. The Context

The context of the project presented in this work is analyzed in two different aspects. The first is the technological platform and the second the digital contents on Electrical Engineering it hosts.

2.1. Technological Solution – the Maxwell System

The technological solution used for this project is the Maxwell System (http://www.maxwell.vrac.puc-rio.br/). It is a large and complex system that combines an IR, a LMS, a subsystem to manage administrative documents and a library of external links of interesting sites. Though the system is currently under the Vice-Presidency for Academic Affairs, it was initially created at the Electrical Engineering Department.

The first version of the system was deployed in the mid 1990s and it was a digital library of courseware in Electrical Engineering. Courseware at that time was very simple since IT tools were more limited. In 1999, PUC-Rio registered the system in the Brazilian Patent Office. As time went by, other types of functions were added as well as other types of contents started being published. Currently the main features of the system are:

- LMS Features

The system offers two "rooms": a Classroom for courses that use ICT tools to support and enhance traditional face-to-face classes and a Virtual Room for distance or blended learning courses. The Electrical Engineering faculty started three undergraduate blended learning courses in 2014, one in the first semestrer of 2015 and will offer one or two more in the second semester of 2015. There are functions to track the students usage of contents. The usual communication tools are avaliable – discussion forum, chat, bulletin board, etc. In the administrative side, there is an agenda, a course schedule, records of grades, a calendar of events and others.

There are administrative tools for instructors and for system administrators. The system is compliant with the univeristy administrative systems.

- IR Features

All contents that are stored and made available through the Maxwell System are described according to national and international standards or best practices. The system is compliant with three metadata standards: DCMES – Dublin Core Metadata Element Set (ISO 15836) (http://www.dublincore.org/) , ETD-ms – an Interoperability Metadta Standard for Electronic Theses and Dissertations (http://www.ndltd.org/standards/metadata) and MTD2-BR – Padrão Brasileiro de Metadados para Teses e Dissertações (http://oai.ibict.br/mtd2-br/MTD2_Fev2005.doc). The last two are specific for online theses and dissertations (ETD); one is international and the other is Brazilian. The description of courseware has many elements of the LOM Standard [3].

Concerning interoperability with other repositories and union catalogs, the system is an OAI-PMH – Open Archives Initiative Protocol for Metadata Harvesting (http://www.openarchives.org/) data provider. It provides metadata of all contents in the DCMES set and of ETDs in both DCMES and MTD2-BR sets.

The current collection has over 19,000 titles. The largest subcollections are:

- ETDs – over 7,300 (ETDs have been mandatory since August 2002)
- Senior Projects – over 3,600
- Courseware of different natures (texts, videos, interactive modules, simulators, etc) – over 2,500
- Articles and other journal contents – over 1,500

Courseware is mostly concentrated in Electrical Engineering topics. For this reason, the system offers an interface that is an aggregator of all EE contents it hosts. It is called *Elétrica On-line* (http://www.maxwell.vrac.puc-rio.br/eletricaonline/) and through it the user can access ETDs, senior projects, courseware, articles and external links of EE contents that are in Open Access.

Two undergraduate and one graduate courses are using videos to substitute for traditional face-to-face lectures. Currently there are 34 videos of the Electric and Electronic Circuits course (one more is under development) and 22 (approximately 25 more to come) of the the Substations and the Distribution of Electrical Energy courses. In the second semester, one more course in the area of Power Systems will use videos. These videos are not assets because they are managed by the LMS.

2.2. Courseware in Electrical Engineering

As mentioned in the previous subsection, most courseware is in Electrical Engineering. In order to set a designation for the courseware, the term LO will be used. It was chosen because the courseware is not SCORM compliant. All LOs are "seen" and delivered by the LMS. Over and above, each LO is described on the IR; LOs can be searched and retrieved by the regular IR functions.

This is an interesting characteristic of this model – integration of an IR and an LMS – it allows courseware to be available to users even when they are not students in a class. The system has five access levels and the author decides which one each LO will have. The choice of access level is used to all contents on the Maxwell System, not only to LOs. Even if LOs are restricted to some users, they can be searched and found, and their metadata can be examined. Access statistics are applied to LOs as well as to other titles of the collection.

Development of courseware is expensive and time-consuming. It involves different profiles of professional staff – content developers, web designers, programmers, experts in interactive modules, animation programmers, etc. for this reason, reuse is so important. All the actions related to reuse of courseware on the Maxwell System [7] - [10] focused on LOs. Examination of the contents of LOs indicated that some "parts" were common to many; one example is the schematic representation of the RLC series circuit and a second example is an input-output block diagram representation. These parts were native of the LOs and were created with them. This led to useless work that could have been avoided. The solution of this problem is addressed in section 3.

2.3. Description of the Courseware on the Institutional Repository

The DCMES and all other metadata sets have an element called "type" whose objective is to describe the nature of the resource. The vocabulary for this element can be found in section 7 – DCMI Type Vocabulary of DCMI Terms (http://dublincore.org/documents/2012/06/14/dcmi-terms/?v=elements#type). The vocabulary has the following set of terms: (1) Collection; (2) Dataset; (3) Event; (4) Image; (5) Interactive resource; (6) Moving image; (7) Physical object; (8) Service; (9) Software; (10) Sound; (11) Still image; and (12) Text. Each term may identify many different types of contents. One example is text that can be a thesis or an assignment or an article or a book or etc, a second example is moving image that can be a video or an animation. For this reason, the Maxwell team added subtypes to each type. Subtypes have the purpose of making the description more specific. A third classification of a content is associated with its conceptual nature – two examples are scholarly publications and technical documents.

Thus the description of all contents on the system is very detailed and precise. But this description did not apply to the "parts" that were native of the resources and therefore embedded in them. These parts are identified as "assets" in the SCORM classification. It is important to remember that they are not managed by the LMS; but they can be managed by the IR. This is a very interesting and important feature of the system – integration of two management systems.

In order to bring efficiency to content development, the concept of asset was added to the system. The description of an asset follows the same practice of any other digital resource, except that a Bollean Variable is associated to the description to indicate that the digital content is an asset (or not). Section 3 describes how assets are being added to the system.

3. Assets

Once the problem was identified – how to reuse assets in the creation and implementation/development of LOs, it was necessary to solve it. The solution was divided in three parts:

- Part one was to consider assets as digital contents that are marked as such on the database of the IR – an enhancement of the data model was necessary. The decision was to use a Boolen Variable to tell if a resource is an asset. Besides this asset identification of the digital file, all description is like that of any other resource. This part addressed the modeling of assets on the system database and it is finished.
- Part two is to find assets in LOs and extract them to be described and saved. Since the number of LOs in large, the decision was to start with the ones that last longer; this means the ones the are not discarded at the end of each school term. When they are described, they receive a number on the IR – it is sequential and is in the same counting of all other resources. At this stage, the LOs that contain the assets are recorded so that part three can be implemented. Part two is under way due to the large number of LOs available on the system.
- Part three is to describe the relations of each asset with the LOs. To understand part three, it is necessary to consider the DCMES element which allows the specification of relations among contents. In section 2 – Properties in the / terms / name space of the DCMI Terms (http://dublincore.org/documents/2012/06/14/dcmi-terms/?v=elements#type), some possible relations are presented. This does not mean that new relations cannot be introduced, since the standard is open for local adaptations. In the standard, there is a set of relations "hasPart" and "isPartOf". This set was used to describe relation among assets and LOs. This is not explict on the database, since this relation is contained in a table. Part three is under way since it goes along with part two.

A comment is necessary at this point – all LOs and assets created after the project started are following the identification and relation description practices. So, no new "problems" are being introduced. It is quite interesting that this new view of the management of digital resources has allowed the reuse of assets in the "old" LOs for contents under development.

The following subsections present partial results of parts two and three. The results come from the examination of 51 LOs of different types, objectives, formats and conceptual natures; two are still under development or editing. They were:

- Class notes – 9 volumes (3 titles)
- Sets of proposed exercises – 3
- Tutorials – 2
- Learning modules – 35
- Course guides of blended learning courses – 2

The first three are texts and the other two are hypermedia documents. They were created by eight different authors. One of the Class Notes requires a lot of editing since the author is new in the ICT – Information and Commuication Technology supported learning. It will probably be divided in two different resources – Class Notes and a Set of Proposed Exercises; at the moment it is still one document.

The number of assets is 602. This means the average number of assets in this set of LOs is almost 11.8 per LO. The following subsections address the redundancies, reuse, etc that are a consequence of this analysis. The work is under way.

3.1. Types and Subtypes of Assets

This is a work under way, so the results are partial and will change. The types and subtypes of assets that were identified in the 51 LOs were:

- Interactive resource – simulator
- Moving image – animation
- Moving image – video
- Software – routine
- Still image – block diagram
- Still image – graphic
- Still image – photo
- Still image – schematic representation of circuits and/or motors
- Still image – screenshot
- Still image – simulation diagram

It is important to remark that the videos that were mentioned in 2.1 are quite different from the ones that are assets. They are longer since they present a full lecture and are managed by the LMS. The videos in the previous list are assets because they are short, address a specific topic and are embedded in a content (a learning module or a course guide); the LMS does not "see" them.

3.2. Digital Formats of Assets

The assets were found in a variety of formats.

- Interactive resource – simulator: html (html5)
- Moving image – animation: html (html5)
- Moving image – video: flv and mp4
- Software – routines: m (MATLAB® format)
- Still images – docx, gif, jpg and png

The formats used for still images deserve a special comments.

- Most textual documents were written using MS Word® and then converted to pdf/A. For this reason, many graphics and block diagrams were objects in the files that had been drawn and could be edited using the Drawing Tools. In order to make them reusable, the original object was saved in a separate file in docx format and a png file was generated to be used in other LOs. The original docx files were maintained due to the ease of editing. In this case, the metadata description informs the existence of two digital format files of the same resource; this is usual in digital collections management. An example of such situation is the block diagram representation of an input-output relation of a linear time-invariant monovariable system – it existed in 10 different LOs; the png asset substituted for them.
- Many graphics, block diagrams and schematic representations of circuits were drawn using PRESTO [11], a tool that was developed by two undergraduate students that were members of the Maxwell System team. The corresponding images were saved either in the png or jpg formats.
- Many still images were difficult to draw and a designer had created them under the supervision of the author(s). These are either in png, jpg or gif formats. Many have more than one format; the metadata description contains such information as in the previous case.
- Many textual documents had images that were hand drawn and scanned. These are undergoing one of the three previous processes.

Some examples of assets follow.

Example 1: Two simulators. One (figure 1) is of an RLC series circuit and the other (figure 2) of a Mass-Spring-Damper system – they are interactive resources, each one is used (embedded) in two different learning modules and they are programmed in html5. It is importante to remark that they use the same code – only the screens are different. This means the code is used in four learning modules.

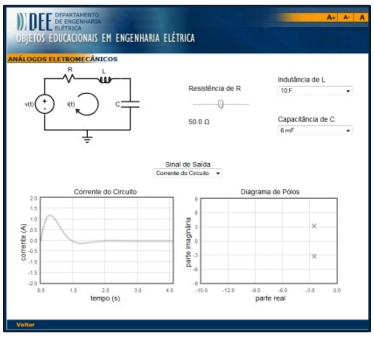

Figure 1 – RLC Circuit Simulator.

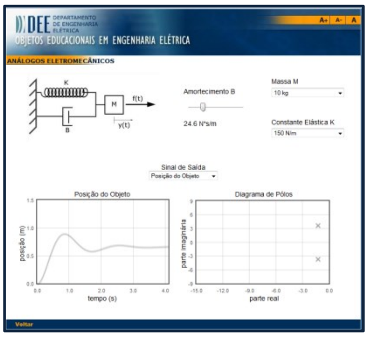

Figure 2 – Mass-Spring-Damper System Simulator.

Example 2: Two videos. One (figure 3) about eigenvalues and eigenfunctions and the other (figure 4) about LDR – they are moving image (+audio), each one is used in one module and their format is mp4.

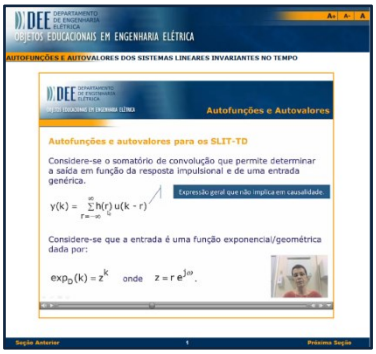

Figure 3 – Eigenvalue and Eigenfunction Video.

Figure 4 – LDR Video.

Examples 1 and 2 show quite elaborate assets. The next example shows simple assets.

Example 3: Four images. One (figure 5) is the schematic rerpresentation of an RLC circuit; used 21 times. The second (figure 6) is a drawing of a thermoelectricity phenomenum; used twice. The third (figure 7) is a graphic; used 10 times. The last (figure 8) is a screenshot of an audio signal analysis; used twice. They are still images and some are pgn and others gif.

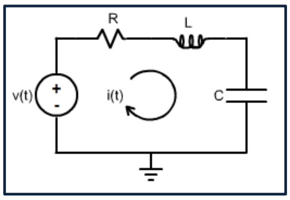

Figure 5 – RLC Circuit Schematic Representation.

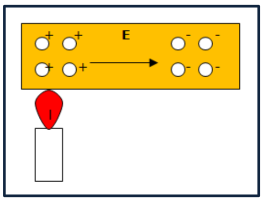

Figure 6 – Thermoelectricity Phenomenum Drawing.

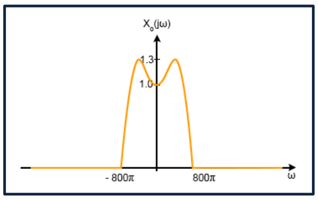

Figure 7 – Graphic.

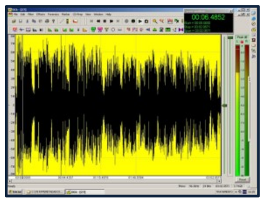

Figure 8 – Screenshot Audio Signal Analysis.

At the moment, a group of undergraduate students is working to develop exercises using SciLab (http://www.scilab.org/). They are working with topics in Controls and Servomechanisms. The exercises will be added to the Maxwell System either as assets in the course guide (of the blended learning courses) or in the learning modules. So, software assets with a sci extension will be added to the IR.

A comment is important concerning the participation of students in the creation and development of courseware – undegraduate students have been very active members of the development team. They create, implement and test courseware of various natures.

3.3. Metadata Description of the Assets

The assets are described using the metadata set that the system supports. The access levels and the possibility of sharing the resource are used too. The relation information is not new to the system either. The only additional information is that the resource is an asset. This has two objectives. The first is for the set of search programs that are used by the general public not to search the assets collection. The second is for searches for assets to find the files – this will help content developers (reuse what they need). When a docx file is available, the author may modify the content and create a new asset, as long as the original author grants this permission.

3.4. Current Numbers of the Assets

As mentioned before, this is a project under way and it has a huge backlog. This backlog is due to the many years of courseware development with no concern on reuse of assets. All focus on reuse was on LOs [7] – [10]. Currently, there are two actions that run in parallel.

- The first action refers to new LOs developed after this project started. All assets are identified and managed by the system. This will be a permanent action.
- The second action addresses the problem of all assets that exist in LOs tha have been developed over the many years. The creation of an assets collection in Electrical Engineering requires the following steps to include the “old” assets:
  - Examine all LOs to find assets in each one.
  - Extract the assets from the LOs – in some cases the procedure follows the specification presented in subsection 3.2 concerning LOs whose priginal format was MS Word®.
  - Create the digital files that correspond to each format of each asset.
  - Describe each asset on the system and upload the digital files.

Both actions are under way and the results, in terms of numbers, are shown below. Table 1 contains the numbers of identified assets per type. All numbers are changing as the work progresses.

- Assets that have been found (old and new) up to now – 768
- Assets that have been described (using a spread sheet) – 424
- Number of LOs containing the 424 described assets – 51
- Average number of described assets per LO – 8.31
- Number of uses of the described assets – 602
- Average use of a described asset – 1.42
- Assets whose files were extracted and/or generated and that were added to the system – 151

Table 1. Numbers of described assets per type.

Types	Numbers	%
Interactive resource	17	4.0
Moving image	54	12.7
Software	8	1.9
Still image	345	81.4
Total	**424**	**100.0**

There is still much work to do concerning the assets that were found but not identified/described. Besides this work, there are over 250 assets that require extracting and cataloging on the IR. And then, there ar many other LOs to examine. There is no doubt that the numbers will change.

3.5. Managing Assets in the IR

Lloyd [12] defined **“Structured content is that which has been classified, and stored in a way that makes it easy to be found and used. Unstructured content is all other content.”** All courseware on the Maxwell System are structured content since they are desscribed using a metadata set with many elements and compliant with international standards and practices. At the same time, assets were not “seen” by the IR side of the system, since they were embedded in other contents. By creating a colletion of assets, they became structured contents that can be found and used. The system is ready to deal with all types of digital contents. It offers many functions to different types of users. They include search functions over the complete set of digital resources that are cataloged on the system. Once assets started being cataloged, the search functions applied to them. At the same time, some functions will be modified to filter the results to retrieve assets only – they will useful to content creators who will want to know what is available. Another enhancement on the search & retrieve functions will to automatically display the asset(s) with the results. The development of new functions is under way.

4. Comments and Next Steps

The decision to start this project seems to be right. The discovery of such high number of assets in the LOs in Electrical Engineering indicates that more LOs can be developed using them. The fact that they are becoming structured contents means that they can be searched and found. One remark is important – the assets are still assets, i.e., they are not managed by the LMS part of the system. The management of the assets by the IR part of the system made them structured contents.

There is still a lot of work to be done concerning the LOs that were created before the project started. This work will be performed because the results will yield productivity gain in content creation. Authors will benefit. The next steps concerning the system are to develop some statistics on the nature, subject, etc of the assets. One special information is of paramount importance – the current degree of reusability of assets. This can be found by the proper analysis of the relations among resources that are recorded on the database. Information on authors allowing reuse and/or creation of new assets based on the original works will help reusability.

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