AN INTEGRATED MODEL TO MANAGE COURSEWARE AND ITS USE IN ICT SUPPORTED LEARNING: AN EXAMPLE IN ELECTRICAL ENGINEERING

Ana M B Pavani – apavani@puc-rio.br
Pontifícia Universidade Católica do Rio de Janeiro
Rua Marquês de São Vicente, 225
22451-900 – Rio de Janeiro – Rio de Janeiro

Abstract: *This work presents the characteristics and the results of deploying a platform that integrates functions of different types of systems used in ICT supported learning and teaching. The functions are the ones offered to: (1) host, manage and access learning contents; (2) be engaged in the learning process; (3) simulate; and (4) experiment. It also addresses the decisions that were made to develop courseware and the way the platform manages contents. Results and numbers are shown. The results address the accomplishment of the proposed tasks, the numbers of learning contents and accesses to ones in Open Access in the year of 2017 until July 16.*

Keywords: *Learning Management System, Institutional Repository, Courseware Development, Management.*

1 INTRODUCTION

Development of courseware is time and resources consuming, and requires teams with different and complementary skills. This is widely known by all involved in this activity. For this reason, it is very important that besides fulfilling students and faculty immediate needs, courseware can be shared and reused by other faculty and students in additional courses.

ICT – Information and Communication Technology offers a wide range of products to create, manage, distribute, share and preserve resources. Resources can be traditional texts in digital formats, hypermedia topics, animations, simulators, interactive exercises and remote laboratories. In creating an ICT supported traditional face-to-face course or a blended learning course (b-learning) or a distance learning course (e-learning), different types of resources are available and can be combined.

ICT also provides platforms for students and faculty to use resources and to support the learning process. The platforms host the environment for access to contents, assessment, communication among the players and also administrative functions.

There are many functions in the deployment of ICT supported learning; all are necessary to accomplish the final goal – offer students and faculty the best possible solution to their needs.

This work focuses on one aspect among the many necessary – an integrated model to manage courseware and its use by students and faculty. It is divided in 4 sections besides this introduction. Section 2 addresses the basic definitions necessary to understand the solution. Section 3 presents the context at the university where it is implemented. Section 4 introduces the solution and shows numbers of courseware items and their use, including the offer in Open Access. Section 5 briefly comments the results and discusses the next steps.

2 BASIC DEFINITIONS

The title of the work contains the expression "integrated model". It refers to the combination of two technological platforms that are quite common but in general are implemented separately. They are defined in subsection 2.1. They are "populated" by contents that have specific characteristics; they are defined in subsection 2.2. Subsection 2.3 presents two other platforms that require functions from the former and also contents in order to operate, thus they rely on the first two. Subsection 2.4 comments the topics presented in the previous subsections.

2.1 Institutional Repository and Learning Management System

This subsection defines two different software infrastructures to manage contents and their users.

Institutional Repository

Institutional Repository (IR) is a name well known in the digital library and the publishing communities. It was created by LYNCH (2003). 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 clearly indicates that an IR manages digital materials created by the community of an institution – this means that courseware can be managed by the IR.

Learning Management System

Learning Management System (LMS) is a term well known by a different community – that of persons involved with ICT supported learning. A good definition of LMS (WRIGHT *et al*., 2015) is:

"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."

This definition is broad since it contains all three possibilities of ICT supported learning and teaching. Though others exist, it is good enough for this work.

2.2 Learning Object, Shareable Content Object and Asset

While subsection 2.1 addressed the definitions of infrastructure, this subsection is concerned with the definitions of contents. There are many variations on the definitions but three are quite important.

Learning Object

Learning Object (LO) is a definition that comes from IEEE LTSC – The Institute of Electrical and Electronics Engineers Learning Technology Standards Committee in page 1 of its IEEE Standard for Learning Object Metadata (IEEE LTSC, 2002). It is:

"For this standard, a learning object is defined as any entity – digital or non-digital – that may be used for learning, education, or training."

This definition is quite interesting when Engineering Education is under consideration since it allows non-digital artifacts to be classified as LOs. This is the case of Remote Labs and physical models, for example.

Shareable Content Object and Asset

The definition of Shareable Content Object (SCO) comes from a large project called SCORM – Shareable Content Object Reference Model (ADL, 2004). The definition is:

“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.” (page 11-4).

The same document contains two additional definitions: SCO in page 3-3 and Asset in page 3-2. They are:

“SCOs are the smallest logical units of information you can deliver to your learners via an LMS.”

“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.”

Other Concepts and Comments

Sharing and reuse are so important that other authors devoted time to their study. WILEY (2000), in his PhD Dissertation, introduced the terms reusable chunks of instructional media, reusable instructional components, reusable digital resources, reusable learning objects (LO). Another term, Reusable Learning Objects (RLO), was created by ALSUBAIE (2009).

It is quite obvious that managing courseware is a concern of those involved with the development and the use of this type of digital contents. Enhancing sharing and reuse should be a target. This was indeed a target in the implementation of the solution presented in this work.

2.3 Numerical Solution Software and Remote Laboratory

Engineering Education requires other activities that must also be made available when it is ICT supported. Two important types of modules to be integrated are numerical solution software products and Remote Labs.

Concerning numerical solution software products, two types can be identified. The first is of general purpose products and there are many available both commercial (p.ex. MATLAB® and Maple®) and free and/or open source (p.ex. SciLab® and GNU Octave). The second is the set of products that support specific types of applications and there also are commercial solutions (p.ex. CircuitLab® and Cadence®) and free and/or open source ones (LTspice and Fritzing).

When the Remote Labs are considered, a clear definition of the meaning of this name is necessary since sometimes Remote Labs are confused with Virtual Laboratories, which are purely software based. An interesting classification is found in (Heradio *et al.*, 2016). It is based on their physical natures and the ways they are accessed:

- Local Access – Real Resource
- Local Access – Simulated Resource
- Remote Access – Real Resource
- Remote Access – Simulated Resource

In this article a Remote Lab is the third in the list – it is real and remotely accessed.

2.4 Comments on the Topics in this Section

The objective of this section was to introduce the idea that ICT supported learning requires both platforms and contents. In this work, contents will follow the IEEE LTSC definition of LO since Engineering Education must use non digital products too (like the physical components of Remote Labs). It is just an obvious remark that the third requirement is people – students, faculty, content developers (authors, instructional designers, technical staff, etc.).

3 THE CONTEXT AT THE UNIVERSITY

Pontifícia Universidade Católica do Rio de Janeiro (PUC-Rio) has held activities in Engineering Education since the 1990s. The activities are of different natures – one example is PBL (both Problem and Project Based Learning). Another area that has had a lot of attention is ICT supported learning.

Activities in ICT supported learning started in the 1990s and have been centered in Electrical Engineering and related curricula (Computer and Control & Automation). Courseware has been under development since then though the old items have been discarded due to technological limitations – they were a lot simpler than what can be developed today and also many were based on products that are not in use or tend to be not in use in the near future. Interactivity had to and was indeed introduced in many contents since this stimulates their use by students; current technology supports interactivity of different types a lot better than some years ago.

In 1995, the Maxwell System (https://www.maxwell.vrac.puc-rio.br/) started being deployed as a digital library to manage courseware in Electrical Engineering – both the system and the courseware were simple; technology was quite limited at the time and network speed was low. As time went by, the system aggregated many functions to support not only content delivery but the learning process. All functions available from LMSs were incorporated. Currently, there is a *Sala de Aula* (Classroom) to support traditional face-to-face courses, a *Sala Virtual* (Virtual Room) for b and e-learning, and a *Lab Remoto* (Remote Lab). The three environments offer chat, discussion forum, bulletin board, agenda, calendar, scheduling of activities, etc. Support to traditional courses started when the LMS functions began being added; e-learning courses (extension level) began in 2011; b-learning (undergraduate and graduate levels) in 2014, and a remote lab in 2016.

In order to support all this activity, a group of faculty, graduate & undergraduate students, and technical staff engaged in the development of a large number of learning contents of many different natures.

The IR side of the Maxwell System is of paramount importance in managing the learning contents – levels of access, sharing, reuse and easy of use solutions.

This work addresses this context – independent management of contents (courseware), independent management of users (students, faculty and technical staff), independent management of other resources (SciLab® and VISIR) and integrated management of all three.

VISIR – Virtual Instrument Systems in Reality is the remote lab for Electric and Electronic Circuits that was installed and started operating in 2016. An online report of the implementation is available on the Maxwell System (https://www.maxwell.vrac.puc-rio.br/VISIR/index.html).

Both content development and management are addressed in the following section.

4 DEVELOPMENT AND MANAGEMENT OF COURSEWARE

Courseware is a very important component of all the activities related to ICT supported learning. For this reason, development and management of learning contents are key factors when many curricula, courses, classes, authors and instructors are involved. A well-structured management enhances productivity of the process.

The Maxwell System offers functions of management of contents with two main characteristics: (1) a content is an independent item on the IR collection; and (2) items can be combined (aggregated) to become parts of journals, collections, modules and/or syllabi; the combination is performed through the use of tables on the database that are fed using programs operated by end-users (no IT personnel is required to describe and combine contents!). There are different levels of aggregation. For example, articles are aggregated to yield numbers/issues which in turn are combined to become a journal. In terms of learning materials, items may be aggregated to generate modules which are combined to fulfill syllabi of courses. In the case addressed in this work, there is an additional type of item that has a special treatment by the system – the Asset.

This characteristic that items do not belong to courses and are not deposited in their folders allows share, reuse and easy maintenance – updates are performed in only one digital file though it can be used in many contexts. There is no replication of files. It is obvious that this characteristic requires a rigid version control and the IR supports it. This indicates the importance of having the IR and the LMS integrated in a single platform.

4.1 Digital Contents

Digital contents are analyzed from two different points of view. The first refers to the types that are used, the contexts of use and the way they are created and implemented. The second is their management.

Types, contexts, creation (authorship) and implementation (development)

An interesting view on who the developer of ICT supported learning materials should be (ALESSI & TROLLIP, 1991) is the choice between a subject-matter expert who learns about courseware development or a designer to studies and learns the content. The author's opinion is that besides being an expert on the topic, the developer must be experienced in teaching it. This requirement yields a knowledge of topics students have more difficulty, of ICT solutions that help the understanding of concepts (p.ex. animation, simulation and interaction are very necessary in learning dynamic phenomena) and of points that must be assessed to check the effectiveness of the learning process.

It is important to remark that the Maxwell System collection began to host contents in Electrical Engineering and this has been maintained. Courseware is focused on EE and related areas – Physics (Electricity and Magnetism) and Control & Automation. An important characteristic of the university is that the curricula of three engineering programs share many courses – Electrical Engineering, Control &Automation Engineering and Computer Engineering. For this reason, courseware for these courses can be used by many students.

The option was for the developers to be faculty who teach the courses; to support them in the very early years (late 1990s and early 2000s) an instructional designer joined the group. From then on, faculty are authors or authors and developers. Faculty are developers when it comes to videos that are recorded and edited using personal computers. Developers are students (both undergraduate and graduate) in the mentioned areas. They are a very special type of developer because they master the technology tools, they know contents they are working (they can review!) and also understand the difficulties students have. They suggest topics they think are important and are authors too. Both activities (authorship and development) are accomplished through internships or extra-curricular activities.

Courseware has been under development for over two decades. In this time spam not only ICT has changed as never thought but the objectives of the courseware have changed too. The new technological platforms, the faster networks and the new students demands have allowed a wider objective for the group. Current students were born in a digital world and master ICT tools; they also require richer technological solutions.

To support the new demands, b-learning and the Remote Lab were introduced and they required new types of learning materials. Currently, learning contents are very diverse. There are many texts (classnotes, exercises assignments, lab guides) that are digital formats of traditional printed materials.

At this point, it is interesting to make a historical remark about digital libraries and their availability on the Internet in the last years of the 20th century (CANDELLA, CASTELLI & PAGANO, 2015). The authors remark that in the beginning of the 1990's research on digital libraries began and many systems devoted to support them were developed. The digital collections held texts and images, i.e., they were digital versions of conventional items.

At the same time, ICT opened a wide range of options that are only possible in digital formats (they are born digital items) and they can fulfill the needs of b-learning, besides enhancing traditional face-to-face courses. Faculty, students and the Maxwell team have been very active in developing courseware based on the new technological resources. This courseware is of many different natures and addresses varied learning objectives.

Table 1 shows the numbers in each type; some are collections of smaller educational resources.

Table 1 – Numbers of learning contents by type.

Type	Number
Video Class	99
Hypermedia Course Guide(1)	2
Interactive Book of Electrical Eng (2)	4
Hypermedia Learning Object(3)	86
Simulator Object(4)	28
VISIR Courseware(5)	27

(1) Containing general concepts, suggestions of activities, links to other courseware on the Maxwell System and on other repositories, and 35 short videos.
(2) 712 interactive exercises with, at least, three options of parameters and/or functions in each one.
(3) 77 in Portuguese and 9 versions into English.
(4) 18 in Portuguese and 10 versions into English. There are 80 simulators in the 18 original objects.
(5) Assorted materials developed to support specific activities of remote lab VISIR.

Most courseware is available in Open Access (OA) and can be reached by clicking OER (https://www.maxwell.vrac.puc-rio.br/oer.php) in the left hand side menu of the system. OER is the acronym of Open Educational Resources. There are many international OER projects. Two examples are MERLOT – Multimedia Educational Resource for Learning and Online Teaching (https://www.merlot.org/) and OER Commons – Open educational Resources (https://www.oercommons.org/).

Assets are an important type of digital files associated with courseware. They were defined in section 2.2. From their definition it is clear that an LMS does not manage them since they do not have educational purposes. But they are important because they are embedded in learning contents and a large number of them are used many times in different learning contents. Assets are graphics, block diagrams, schematics, code, animations, small html5 simulators, hypertexts with basic concepts, etc. They are not elements that combine to fulfill a syllabus so they are dealt as a special entity on the system. They are addressed in the next section.

Management of all digital materials

The Maxwell System is a combination of an LMS and an IR. The IR "side" of the system is responsible for the management of contents. In order to be an IR, it fulfills some requirements that are best practices for IRs. They are:

- It supports the metadata element set known as Dublin Core® which is the DCMES – Dublin Core Metadata Element Set (ISO15836/2003). This is a minimum set that can be used with many additional elements proposed by the organization (DCMI – Dublin Core® Metadata Initiative – http://www.dublincore.org/) that maintains the standard. It is also extensible. This last characteristic allows elements to be introduced according to the local requirements and this has heavily been used on the Maxwell System. The decision was to add elements that are relevant to the management of learning contents and of the university.
- It supports two other metadata standards: (1) MTD-BR2 – Padrão Brasileiro de Metadados para Teses e Dissertações (http://bdtd.ibict.br/); and (2) ETD-ms – an Interoperability Standard for Electronic Theses and Dissertations (http://www.ndltd.org/). These sets are necessary because theses and dissertations in digital formats are deposited and made available from the system. ETDs started being published by the system in 2000 while the pilot project of ETDs started in 1996 (CANDELLA, CASTELLI & PAGANO, 2015).
- It uses many elements that belong to LOM (IEEE LTSC, 2002).
- It is an OAI-PMH – Open Archives Initiative Protocol for Metadata Harvesting (http://www.openarchives.org/) data provider. This means that metadata from all contents on the system can automatically be harvested and transferred to national and international union catalogs of metadata.

These characteristics are important because they allow a thorough description of all digital contents which, in turn, is a key factor for their use, not only for the search and retrieve functions but also for the flexibility in combinations (aggregations) to yield, collections, modules, etc. A good example follows.

Example: **Video Classes, Hypermedia Learning Objects and Simulator Objects**

The total number of these objects is 219. Among these, 19 are versions into English and the remaining are originals in Portuguese. The video classes are not all in OA – 55 are restricted to students in the classes of some b-learning courses. The objects are used in the following ways:

- 35 videos are aggregated in the series *Circuitos em Video* which is in OA. Among the 35, the usage is:
  - Required contents for one b-learning class of *Circuitos Elétricos e Eletrônicos* – 35
  - Supporting materials for Remote Lab activities of two classes of *Circuitos Elétricos e Eletrônicos* – 2
  - Supporting materials for Remote Lab activities of 14 classes of *Eletrotécnica Geral* – 5
  - Supporting materials for Remote Lab activities of two classes of *Medidas Elétricas e Magnéticas* – 7
  - Supporting materials for Remote Lab activities of 14 classes of *Introdução à Engenharia (EE)* – 2

The important fact about the sharing of the objects is that they were not replicated; each one has only one instance.

- 54 hypermedia learning objects are aggregated in the series *Objetos Educacionais em Engenharia Elétrica* which is in OA. Among the 54, 45 are in Portuguese and are used in the courses of PUC-Rio. The usage of the objects as supporting materials for courses is:
  - One b-learning class of *Circuitos Elétricos e Eletrônicos* – 18
  - Remote Lab activities of two classes of *Circuitos Elétricos e Eletrônicos* – 2
  - One b-learning class of *Sinais e Sistemas* – 17
  - One traditional class of *Controles e Servomecanismos* – 16
  - Remote Lab activities of 14 classes of *Eletrotécnica Geral* – 3
  - Remote Lab activities of 2 classes of *Medidas Elétricas e Magnéticas* – 3
  - Remote Lab activities of one class of *Introdução à Engenharia (EE)* – 3

  As before, there is no replication.
- 28 simulator objects are aggregated in the series *Simulações em Engenharia Elétrica* which is in OA. Among the 28, 18 are in Portuguese are are used for the courses at PUC-Rio. The usage of the objects as supporting materials for courses is:
  - Remote Lab activities of two classes of *Circuitos Elétricos e Eletrônicos* – 2
  - Remote Lab activities of 14 classes of *Eletrotécnica Geral* – 1
  - Remote Lab activities of 2 classes of *Medidas Elétricas e Magnéticas* – 3
  - Remote Lab activities of one class of *Introdução à Engenharia (EE)* – 2
  - One b-learning class of *Sinais e Sistemas* – 7
  - One traditional class of *Controles e Servomecanismos* – 8

  As before, there is no replication.

Figures 1, 2 and 3 show an example of sharing and reuse – simulator object *Circuitos com Diodo* in the Remote Lab of *Introdução à Engenharia (EE)*, the b-learning course of Sinais e Sistemas and in the Remote Lab of *Eletrotécnica Geral*. They show two different environments of the system – *Sala Virtual* and *Laboratório Remoto*, both introduced in section 3.

Figure 1 – Simulator *Circuitos com Diodo* in the Remote Lab of *Introdução à Engenharia (EE)*.

Figure 2 – Simulator *Circuitos com Diodo* in the b-learning class of *Sinais e Sistemas*.

Figure 3 – Simulator *Circuitos com Diodo* in the Remote Lab of *Eletrotécnica Geral*.

There is only one instance of the simulator that is used in different courses. It can also be accessed at https://www.maxwell.vrac.puc-rio.br/29722/29722.HTM. It is shown in figure 4.

Figure 4 – Simulator *Circuitos com Diodo*.

The example showed the use of only one instance of a learning object being used in different courses. This is possible due to the integration of the IR and the LMS functions.

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Concerning metadata exposed and collected by harvesters, the objective is to increase international visibility of courseware developed at the university; numbers of accesses are mentioned later. Another action with the same objective was the registering of the learning resources on MERLOT.

A remark is important – this policy on how materials are handled imposes a lot of work from the information processing staff when materials are created and deployed. At the same time, maintenance work is greatly reduced since there is no replication and modifying contents of a course becomes a matter of changing lines on tables of the database which is done via end user programs. Visibility is also a benefit that comes from the fact that courseware does not have to be confined on a course folder.

Assets have a special treatment – they are described using the metadata the system supports but are classified with a boolean variable indicating they are Assets (PAVANI, 2015). This will prevent Assets from being included as required or supporting materials in the courses – they do not have a pedagogical function. The dealing with Assets is quite new, since it started in 2015. Almost all Assets in courseware created after this year are described, stored and related (**relation** among digital contents is specified in ISO15836). There is a problem with older Assets that are under identification, description, storage and relation specification. Currently, 582 Assets are properly treated on the system. They are of 5 different types (**type** of digital contents is specified in ISO15836) and 16 subtypes.

The standard does not specify subtype but its use was necessary to make the description more accurate. For example, "still image" is a type of the standard, but a still image can be a photo, a block diagram, a schematic representation of a circuit, a graphic, a bond graph, etc. Since identified Assets are related to contents, the system has a program that shows in how many contents an Asset is used. The current use is shown in table 2.

Table 2 – Numbers of uses of Assets.

Numbers of contents	Number of Assets
One content	351
Two contents	140
Three contents	26
Four contents	16
Five contents	3
More than five contents(1)	12

(1) One Asset is used in more than 35 contents.
(2) The total number in the table is not 582 because some Assets have not been related so far.
(3) A small percentage of the Assets that are code have not been processed so far.

4.2 Integration with SciLab®

The need of enhancing the learning options has led to decision of integrating a numeric solution software to the system. The chosen product was SciLab® (http://www.scilab.org/). SciLab® is free and open source software for numerical computation. All simulator objects are based on this product. Students do not access SciLab®, they use the objects on the system which in turn submit the request to the SciLab® server installed on one of the servers. Currently, there are 80 SciLab® pieces of code developed for the simulator objects and they integrate with the system via PHP programs. Each code is an Asset and not all of them are described at the moment.

Though SciLab® is a general purpose software for numerical solution of problems, it was chosen so that problems in many areas could be solved. The simulators are not pure pieces of code. They have theoretical explanations, graphics, diagrams, etc. and yield access to code where user can chose numbers for parameters and/or functions.

The development of the simulators began in 2015; the first object was made available in May 2015. At that time the product was in its version 5.5.2. When version 6 became available in February 2017, all objects were migrated to it.

4.3 Integration with Remote Lab VISIR

Engineering Education is not solely theoretical, it requires experimentation that is to be performed in educational laboratories (FEISEL & ROSA, 2005). The authors classified laboratories in three groups: development, research and educational (instructional). Basic engineering courses, such as Electric Circuits and Control Systems, use educational labs.

Since b-learning has been offered since 2014, it was quite natural to include remote experimentation. Remote experimentation is not limited to b-learning. As a matter of fact, four courses are using VISIR and only one is offered in the b-learning mode.

As mentioned in section 3, VISIR is a Remote Lab for Electric Circuits.

It was decided that VISIR would be used from the same system where the LMS and the IR functions were available. So, VISIR had to be integrated to the Maxwell System. This integration was accomplished in different aspects (PAVANI *et al.*, 2017). The first focused the users and it was accomplished by the total integration with the Maxwell System – all existing functionality was used (scheduling, access to contents, bulletin board, etc). The Remote Lab became one additional learning environment of the system; user control is performed by the original functions. Access to the VISIR experiments was programmed so that the user performs the experiments from the *Lab Remoto* environment on the Maxwell System. To achieve this full functional integration, the IR and the Assets were of paramount importance since documents that are needed to control VISIR (MaxLists, Component List and Configuration Files) are defined as Assets and their numbers on the system are used in the connecting functions developed for the purpose of accessing and performing the experiments. The Assets are grouped under Dublin Core type "collection" and subtypes "technical documentation" and "remote experiment"; it depends on their nature.

4.4 Some numbers

A lot of work is involved in the operation of this model when contents are ready to go online. But, as mentioned before, maintenance is a lot easier and the reuse (for example of Assets) and sharing (for example of learning materials) are indications that this work pays for itself. A third benefit is related to the users – they can access contents, use educational functions, simulate and experiment from a single platform.

The model yields an additional benefit – it allows courseware to be made available in Open Access, supporting students from other institutions. Courseware has many accesses. Table 3 shows some numbers in 2017 (until Jul 16).

Table 3 – Numbers of accesses to some contents in 2017.

Type	# of Accesses	# of Countries
Video Class	3,915	14
Interactive Book of Electrical Eng	6,872	11
Hypermedia Learning Object	995	9
Simulator Object	5,203	38
VISIR Courseware	2,687	14

5 FINAL REMARKS

The model presented in this work has the objective of managing persons, contents and functions in an integrated platform in such way that students and faculty do not have to be concerned with "what is behind the scenes". It has accomplished the objective but there is still a lot to do. One of the main tasks is to finish the inclusion of the large number of known Assets.

A focus has also been placed on offering users more information on the use of the system resources.

Currently the system is under enhancement to implement responsive interfaces since more and more users are accessing the resources from mobile equipment.

A new Remote Lab is under consideration as well as the development of a service broker to manage as many Remote Labs as necessary in an integrated manner.

Finally, it is necessary to keep working with faculty and students to develop new courseware. This is a never ending job.

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