# Building reusable and interactive e-learning content using Web[1]

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**Abstract:** This paper presents the design of a web-based learning content authoring tool as well as the way learners can access courseware material, within the scope of a personalized, yet social, learning environment for vocational training. The authoring tool is intended to be part of the instructional component of the VirRAD European project, where the learning process is inspired by the principles of the Mindful Learning theory and supported by an intelligent learner modelling system. It will enable the creation of Radiopharmacy-related learning content that can be easily accessed and reused. In addition, it will facilitate the monitorship of the users' learning activities.

## 1 Introduction

Nowadays, that the use of Internet has been expanded widely and the time and place limitations are considered as an obstacle to the traditional classroom-based training, technology-based learning, otherwise e-learning, gain continuously the interest of scientific community, organizations and governments. In the recent past, a great number of e-learning platforms has been introduced into the market [1], showing different characteristics and services, according to the pedagogical approach they follow for serving their end-users needs as well as the technological solutions they adopt to support the learning process. The swift growth of technology that is observed the last decade facilitates the incorporation of new services and functionalities in such platforms that could not be even conceived few years ago. As a consequence, e-learning environments are now able to efficiently manage just-in-time learning content [2] as well as pedagogical aspects related to the training process [1].

E-learning environments are expected now, more than ever, to deploy and manage learning content that can be easily searched and retrieved during an auto-learning phase as well as to be reused for different educational purposes. Content's reusability is considered as a crucial factor for the effectiveness of an e-learning system as not only reduces the efforts that have to be paid for the redesign of the learning content but also contributes to the avoidance of content duplication [1]. Moreover, the wide variety of learning resources may disorientate learners from choosing content that best

[1] This work was supported by VirRAD/IST-2001-32291

meets their needs, according to the previously gained knowledge. To overcome this learning obstacle, it is essential to allow the learners to easily locate and access the content of their preference.

Another important functionality that up to date e-learning environments are expected to expose, is the monitorship of the users' interactions with the content [1]. This enables the system to gather information about the learning resources' usage as well as to track and report on learners' progress and performance. Students are then able to consult, at any time, the results they have reached and, consequently, to monitor their preparation level. This information can, also, be exploited by the system in an attempt to diagnose the learners' needs [2] and advice them on the most suitable learning content [1].

A first step towards content's accessibility is the description of the learning resources in a consistent way using metadata. Metadata, or "data-about-data", are defined as the attributes required to fully and adequately describe a learning resource regardless of a specific learning context or a specific educational purpose. Furthermore, as mentioned in [2], the reusability of the learning resources presupposes the presence of an advanced knowledge management system able to categorize, enrich and integrate learning resources. It is, therefore, fundamental for the application of web-based learning to attach metadata to the learning resources. Hopefully, the last years, a lot of effort has been put on the development of learning technology specifications towards this need. Organizations, such as IEEE Learning Technology Standards Committee (LTSC) [3], IMS Global Learning Consortium (IMS) [4] and Advanced Distributed Learning (ADL) initiative [5], have presented remarkable outcomes regarding the development of standard metadata rules able to point out the real semantic content of the learning resources.

A web-based courseware authoring tool, as part of an integrated e-learning environment, able to develop accessible and reusable learning resources, is considered not only valuable for serving effectively the learner's needs but also for facilitating the whole learning process by allowing the monitorship of the learner's interactions with the content. It is one of the technological means that the environment should exploit in order to serve the pedagogical approach it adopts and manage just-in-time learning content.

This paper is dedicated to the design of such a tool, within the scope of a virtual learning environment for vocational training on the radio-pharmacy field. The section 2 of the paper presents briefly the VirRAD European project, in terms of the objectives and expected outcomes, whereas section 3 focuses on the instructional component of the system. Section 4 is dedicated to the design of the authoring tool, as it is envisioned to function, as well as the way in which learners can access the learning material. The fifth section is engaged with implementation considerations. Finally, some conclusion remarks together with the envisioned next steps are presented.

## 2 The VirRAD Project

VirRAD (Virtual Radio-pharmacy) [6] is envisioned to be a virtual learning environment for the vocational training of individuals on the radio-pharmacy field. The learning process will be inspired and conducted under the theories and principles of the Mindful Learning theory as well as other contemporary learning or instructional design theories. Mindful learning theory questions seven myths of the traditional learning and supports experiential learning, enhances learning process through creative distraction and presents an alternative view point, encouraging more flexible learning [7]. Within VirRAD, a multi-layer, meta-cognitive learner modelling system will support the learning process by encouraging individuals to communicate and collaborate with each other, facilitating the learning content access according to each learner's needs, and offering pedagogical advice on the learning material usage. The environment, where the learning process will be realized, will be a virtual space enabling the communication and collaboration among the individuals both in a synchronous and an asynchronous manner.

To meet the aforementioned objectives, VirRAD system has been divided into four main areas, namely Public Website, Community, Instructional Component and Project Internal Site [8].

- The Public Website constitutes the VirRAD's introductory component aiming to invite potential users to the system. It will provide general information on Radio-pharmacy as well as the means for the users to contact the VirRAD team.
- The Community site provides a series of tools for the communication, collaboration and information exchange among the radio-pharmacist's community members. These tools offer functionality such as personal card, library, text chat, virtual conference, forum, news, links, events, adverse reactions reporting system and glossary of terms.
- The Instructional Component of the VirRAD system aims to support and facilitate the access to the learning material through an intelligent learner modelling system, as well as to encourage and facilitate interactions among learners, authors and mentors. The Instructional component will be further discussed in subsequent sections.
- The Project Internal Site provides functionality similar to the Community's but it applies, mainly, to the project members.

## 3 Instructional Component of the VirRAD System

The Instructional component of the VirRAD system concerns learner-learner, learner-mentor, and learner-system interactions as well as the access and the creation of the VirRAD courseware. Within this area, the users of the system can undertake three types of roles: learner, mentor or author.

Each learner has his/her own personal learning profile (e.g. determined through introductory assessments or further registration). S/He can access the available e-learning material, make use of the VR Laboratory (that is subsequently described) and be supported by mentors and the learner modelling system.

Mentors derive the real radio-pharmacists' community and have as main task to support the learners into the instructional component. This is realized in two main modes: asynchronously, via e-mail, or synchronously in the 3D Virtual Teaching Laboratory (this is also described in the next paragraphs).

Authors are members of the VirRAD community that have as main task to provide Instructional material to the learners in the instructional component. They can submit and modify instructional material as well as to attach and edit metadata to the learning resources.

The main functionalities, that the instructional component provide, are:

- *The VR laboratory:* It is a 3D simulation of a radio-pharmacy laboratory, where learners, represented by 3D avatars, can experiment on radio-pharmacy equipment by carrying out specific learning scenarios. The VR Laboratory can be accessed either in a stand-alone or in a multi-user way (VR Teaching Laboratory). In the first case, a learner can interact with the radio-pharmacy equipment and get pedagogical advice by the system or send an e-mail to a mentor requesting further explanations. In the second case, learners can meet, communicate and collaborate with each other and with mentors, as well as get support by mentors on the usage of the 3D simulated radio-pharmacy equipment.
- *The learning management element*: It provides tools for the creation and integration of learning objects and courses into the VirRAD courseware. This element facilitates the access to the courseware and monitors the learners' interactions with the instructional material, while offering them pedagogic advice by means of the intelligent learner modelling system. Learners are able to conduct self-assessments as well as to create, access and edit their own personal academic records, which exchange data with the learner modelling system. The last is divided into two main parts: an active and a static one. The active part is mainly responsible for monitoring and analyzing the learner's interactions with the learning material, while the static one (database) stores information and statistics about the learning activities experienced by a learner. This information is used by the system with the intention to offer pedagogic advice to the learner's best advantage. Furthermore, mentors can support learners by monitoring their personal academic records, answering to their questions via e-mail, suggesting informative learning resources or inviting them in the VR teaching laboratory for further discussion.
- *The courseware:* It comprises the learning content of the VirRAD system. The topics of the content are mainly targeted on the radio-pharmacists' community and therefore they focus on the preparation, manipulation and quality control of potentially hazardous radioactive material. VirRAD system will support a wide variety of content types, such as exercises, slides and 3D simulations (e.g. elution of a generator and contamination monitoring). The courses will be composed of learning objects, which will be accessible and reusable and they could be linked to more than one course.

This paper is dedicated to the design and development of the third functionality. Therefore, the structure of the e-learning content as well as the tools for creating and accessing courses are described in detail, in the following sections.

# 4 VirRAD's Courseware

The courseware within VirRAD is intended to serve the need of the radio-pharmacy community members for just-in-time learning content related to radio-pharmacy. The courseware elements, also called content model components, should be easily merged and aggregated to produce a modular repository of training material, whereas they need to be attached with descriptive information for facilitating their easy access and reuse. Furthermore, according to the Mindful Learning theory, the learners' interactions with the learning material should be tracked by the VirRAD's learning management element. These interactions include the time a learner spends on a learning resource, other similar learning resources the learner selects to view, the content type (e.g. vide or text) delivered to the learner as well as answers to assessment questions. The following subsections present the VirRAD supported content model components and their metadata elements, the way these components can be aggregated to form larger units of instruction as well as the means that enable their access and monitorship in terms of learners' interactions.

## 4.1 Content Model Components

The VirRAD system distinguishes three types of learning content model components, which are involved in the courseware development process. These concern "Assets", "Learning Objects" (including assessments) and "Courses" and they are defined as follows:

- *Assets:* Assets comprise the basic constitutive element of the courseware. They refer to raw media files that can be viewed by a web browser, such as slides, flash objects, exercises and 3D simulations.
- *Learning Objects/Assessments:* A learning object refers to the learning content launched by the learning management element and delivered to the end-user during a courseware learning experience. It can be either a collection of one or more assets or an assessment object. Assessments may contain a question of at least four types, namely multiple-choice (true-false and multiple answer are also included), matching, fill-in-the-blank and open short answer questions (including short paragraph questions).
- *Courses:* One or more learning objects or even courses can be aggregated together to form a cohesive unit of instruction, i.e. a course, dedicated to radio-pharmacists' needs. Within a course, the learning objects and courses will be listed sequentially in an author-defined order. Using a course as part of another course, authors can develop courses nested in any depth and, thus, apply learning taxonomy hierarchy.

## 4.2 Metadata Elements

In order to allow the application of web-based learning and fulfill the requirements for accessible and reusable learning content within VirRAD, there is the need to attach metadata elements to the three previously described content model components. As already mentioned, the scientific community and industry engaged in e-learning

technology area has presented a variety of specifications regarding learning resources metadata. The most significant of them are the IEEE 1484.12.1 Learning Object Metadata (LOM), approved on June 2002 as an IEEE-SA standard, the IMS Learning Resource Metadata Specification and the SCORM Specification.

As described in [9], LOM defines the attributes required so as to fully and adequately describe a learning resource. The IMS Global Learning Consortium based on LOM and slightly modifying it, has developed the IMS Learning Resource Metadata Specification. Finally, the SCORM Specification references the IMS Metadata specifications and applies its definitions to the SCORM' s three content model components. This mapping provides "the "missing link between general specifications and specific content models" [5].

From the above it is clear that the SCORM specification has precedence over the other aforementioned specifications, as it refers to them while making one step further. This is, actually, the main reason why more and more learning technology products tend to be compliant with it [9].

SCORM specification maps the metadata elements to its three content model components, "Assets", "SCOs" and "Content Aggregations", by defining which elements are mandatory, optional or reserved by the system. Assets, SCOs and Content Aggregations are defined as follows [9]:

- *Assets:* They concern learning content in the most basic form that can be delivered in a Web client. Web pages, images and text are few examples of assets.
- *SCOs:* A Sharable Content Object (SCO) is a collection of one or more assets that can be launched by a Learning Management System (LMS). However, as opposite to an Asset, a SCO can communicate with the LMS thus allowing the LMS to track down the learner's interactions with the content.
- *Content Aggregations:* It concerns a content structure that can be used in order to aggregate Web-based learning resources into cohesive instructional units (e.g chapters and courses), define the structure of this unit and associate learning taxonomies. The content structure defines the sequence according to which the learning content will be presented to the user.

As mentioned above, a SCORM-conformant LMS can track the learner's interactions with the content by exchanging information with SCOs. These interactions include the majority but not all the interactions that need to be tracked down according to the Mindful Learning theory. In particular, open short answer questions are not defined in the SCORM specification, whereas information about the alternatives content types (e.g. video or text) the learner selects to view is limited to audio and text preferences only. SCORM supports many more interactions, which, however, are considered out of the VirRAD scope. Using the SCORM Run-Time Environment [5] for exchanging all the necessary information between the delivered learning content and the VirRAD's learning management element, presupposes the extension of the data model proposed by ADL initiative, the implementation of the appropriate (scripting) functions that need to be incorporated into the content, as well as the extension of the ADL's Application Programming Interface (API) to implement the new functionality. Instead, and in attempt to create an auspicious but still simple web-based authoring tool, we appose our solution to simplify the whole process.

In order to apply SCORM conformant metadata to the VirRAD's content model components, we assume the following interrelations:

**Table 1.** Interrelations between VirRAD and SCORM content components

| VirRAD content component | SCORM content component |
|---|---|
| Asset | Asset |
| Learning Object (including assessments) | SCO |
| Course | Content Aggregation |

VirRAD system will support all the mandatory elements for each of the aforementioned content model components so as to assure full compliance with the SCORM Metadata specification. Furthermore, the learning resources will be provided with some optional SCORM metadata elements, which are considered necessary within the scope of VirRAD, as well as with an additional one, called "storyboard". This has been introduced for VirRAD's purposes with the intention to describe what happens in a learning resource. Metadata elements are grouped into nine categories, namely General, Lifecycle, Meta-metadata, Technical, Educational, Rights, Relationships, Classification and VirRAD specific.

### 4.3 Creating Courseware

The courseware material within VirRAD concerns Assets, Learning Objects and Courses targeted to the learning needs of the radio-pharmacist's community members. This subsection presents the way these components are brought to light, during the authoring process.

As already mentioned, assets constitute the basic element of the courseware and they can be of various types. Authors will have the responsibility to upload them into the system (in particular to the Web Server) and enrich them with at least all the mandatory metadata elements, as they have been defined by ADL initiative. Thereafter, authors can assemble one or more assets so as to create Learning Objects (LOs).

In the case where the LO is intended to be an assessment, authors can select one of at least four question types to insert into the assessment. The available question types are envisioned, but not restricted, to be multiple-choice (this also includes true-false and multiple answers questions), matching in two columns, fill-in-the-blank and open short answer questions (this also includes short paragraph questions). Authors need, also, to define the correct answer to the question (or keywords that the answer should include) and, conditionally, the maximum time a student is allowed to view the assessment object until s/he supplies an answer. This information can be used by the system in an attempt to monitor and report on learners' progress and performance. Moreover, assessments may be enhanced with an asset, located in the Web Server, for illustrative purposes (e.g. a graphic).

In the case where the LO is intended to be a collection of one or more assets, the author is provided with a title list of all the assets available in the system's Web server. S/He can, then, select the asset(s) s/he intends to incorporate into the LO and define the way this object will look. This process is facilitated by an ease-to-use

graphical user interface, which aims at alleviating the authoring process by minimizing the author's programming efforts.

In both cases, the whole process terminates with the metadata provision. Thereafter, the system incorporates some scripting functions into the content with the intention to supply the learner modelling system with the appropriate information that it needs to be aware of according to the Mindful Learning theory.

Creating a course within VirRAD involves the aggregation of one, or more, Learning Objects (or even courses) together and the attachment of, at least, all the mandatory metadata elements required to fully and adequately describe this content component. These metadata elements aim to describe the course in a particular context, related to Radio-pharmacy. The way in which authors can aggregate learning resources to develop a course within VirRAD has been inspired but is not identical to that described by IMS Content Packaging and SCORM specifications, due to simplicity reasons. Though, authors can still apply learning taxonomy hierarchy.

In particular, when an author selects to create a course for VirRAD's purposes, s/he will be provided with a list of all the available LOs and courses. S/He can then select the learning resources that the course will consist of, as well as the sequence in which they should be presented to the learners (see Fig. 1). As they are allowed to encapsulate courses in another course, authors are able not only to apply learning taxonomy hierarchy but also to consecutively create larger and larger units of instruction.


**Fig. 1.** Adding LOs to a new course

Besides uploading assets into the system and gradually creating learning objects and courses, authors have also the ability to modify the attached metadata elements, as well as the various learning objects and courses. However, any changes to the learning material are not readily available during content authoring or access, unless approved by the Editorial Board (members of the real radio-pharmacists' community that are involved in the VirRAD project as partners).

### 4.4 Access to Courseware

Any community's member registered as a learner can access the VirRAD's courseware from the Public Web Site. The general access page for all the courseware provides the means for the learners to choose a mode of learning, links to all the available courses approved by the Editorial Board, as well as searching facilities.

Learners can select between two modes of learning while experiencing a course. These concern the "browse mode", where learners are able to jump from topic to topic as they wish, and the "study mode", where learners are motivated to follow the pedagogical advice, provided by the learner modelling system. If the learner accepts the pedagogical advice, s/he can be transferred to another element of the course or part of the community area. In study mode, the learner modelling system will monitor the learners' activities such as what course material they access, for how long as well as their response to assessment questions. This is expected to be the usual mode of using the learning material.

Learners can view the contents of a course by clicking on its title within the general access page. They are, then, redirected to a new web page, which contains the course's table of contents in one frame (in the from of a hyperlink tree) and the real learning content in another frame. The table of content is built dynamically according to the course's structure as it has been defined by authors and stored in the courseware database. Moreover, when a user clicks on the course's title or a topic within the course, a list of links to learning resources that the clicked resource relates to appears in another frame of the browser window (see Fig. 2). The list of related resources is built based on the resource's metadata elements (in particular the elements contained into the Relationships category).


**Fig. 2.** Accessing courseware within VirRAD using browse mode

Users can navigate through the learning objects contained in a course or encapsulated courses, by (a) selecting a topic from the table of contents, (b) using the

"Next page", "Previous page" navigation buttons, (c) following the pedagogical advice or d) following a link form the list of the related resources. The last two ways may guide the learner to another course. The title (hyperlink) of an already visited learning object is highlighted so as to keep the learners informed of all the learning objects they have been delivered. While experiencing a course, learners can change the mode of learning (browse or study) or search for a learning resource.

Learners can search and retrieve assets, learning objects and courses by supplying indicative keywords. As the three content model components within VirRAD are described using metadata, the keywords are searched within these metadata elements. Learners have also the ability to define advanced search criteria such as the title, the type or the author of a learning resource.

## 5 Implementation Issues

The VirRAD system will be based on a client-server architecture. The picture bellow (Fig. 3) presents the part of the system's architecture that is engaged to the courseware element. There the following three components can be distinguished:

- *Web client:* Learners will be able to access the learning content as well as other VirRAD's services through a browser window. Authors can upload assets and create or modify learning objects and courses through a browser window too. The VirRAD system will come with a variety of user interfaces in order to manage the various functions.
- *Web Server:* The Web Server is used, among others, for storing the content of the courseware as well as for storing and executing the scripts of the scripting environment. The Web Server interacts with the browser window using the HTTP protocol and with the database by means of the scripting interface. The scripting environment will provide almost all of the VirRAD's courseware functionality. This includes the implementation of the searching functionality, the building of a course's table of contents and the information retrieval about the resources a LO or a course relates to. Moreover, the scripting interface is expected to send events to the learner modelling system so as to facilitate the tracking of the learner's interaction with the content. These involve the amount of time the learner has spent on a learning object at the time s/he leaves it, the answer s/he supplies to question objects and the time this occurs, whether and what relative resources the user selects to be delivered, as well as whether or not s/he selects to view a particular content type among many alternatives describing the same content (e.g. video and video script). Within VirRAD the Apache web server will be exploited, whereas the scripting environment will be mainly drawn upon PHP scripting language. The events to the learner modelling system will be sent through XML.
- *Courseware Database:* The database management system constitutes the core of the whole system where the majority of the information available is stored and organized. Information related to the courseware element will be stored in the "Courseware Database". This includes information about the available learning resources and their relationships, the metadata elements and data about learner's

activities needed by the learner modelling system. VirRAD will exploit the MySQL database server.

- *Learner Modelling System:* The learner modelling system facilitates the access to the learning material, encourages the communication, collaboration and information exchange among learners while offering them pedagogical advice. It exchanges information with the learners' personal academic records and the database and accepts XML events sent through the scripting interface.

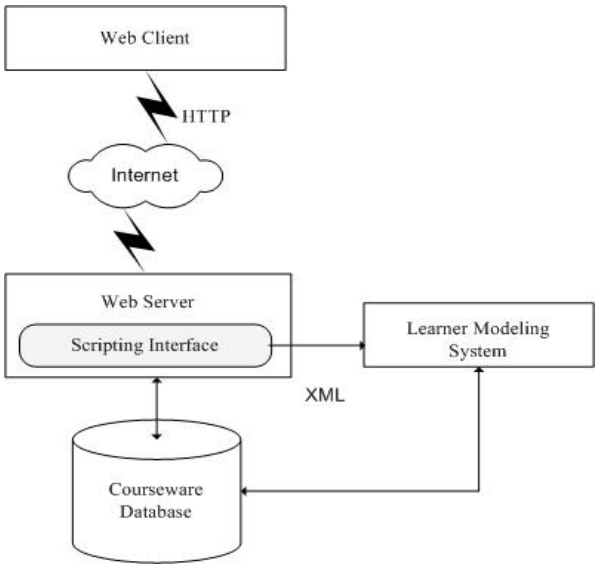


**Fig. 3.** System Architecture concerning the courseware functionality

## 6 Conclusions and Future Work

The swift growth of technology allows up-to-date e-learning environments to incorporate a wide variety of services and functionalities, which enable them to effectively manage just-in-time learning content as well as pedagogical aspects related to the training process. Learning content's accessibility and reusability are considered essential to the success of such an environment as they obviate the danger of the content's duplication, while smoothes the progress of the access to the learning material. E-learning environments are, also, expected, more than ever, to monitor the learners' interactions with the content so as to track and report on their progress and performance in addition to advice learners to their best advantage.

Metadata constitutes an important attempt towards learning content's accessibility and reusability. In particular, SCORM specification regarding metadata references the most significant learning technology specification towards this need, while making one step further by linking the metadata elements to particular content model components. The learning content within VirRAD involves three model components

(Assets, Learning Objects and Courses), which will be attached with SCORM conformant metadata as well as with an optional, VirRAD specific, metadata element.

The web-based authoring tool we have presented is designed to assemble learning resources in a highly modular way and attach them with the appropriate metadata elements. Moreover, this tool allows the creation of assessment questions that facilitate the monitorship of the learners' interaction to the content. The learner modelling system will exploit this information in an attempt to offer pedagogical advice to the learners, to encourage them to communicate and collaborate with each other as well as to facilitate the access to the learning material. Besides the authoring tool, special attention is paid to the learning content access. Learners will be provided with all the means that will help them navigate through a courseware element or access content according to their previously gained knowledge.

The proposed web-based authoring tool as well as the way the learning material will be accessed, constitute an attempt towards e-learning environments' requirements to deploy and manage accessible, reusable and traceable learning content. Our next steps involve the implementation of this tool and functionality within the scope of VirRAD. During this phase, special attention will be paid on the minimization of the programming efforts required by the VirRAD' authors. For the implementation the Apache Web Server, a MySQL database server and the PHP scripting language will be exploited. Furthermore, client-side JavaScript and Cascading Style Sheets could also be used to provide a more flexible, user-friendly and intuitive graphical user interface.

## 7 Acknowledgements

We would like to thank all the VirRAD partners for their collaboration and contribution to our work.

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