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LIMEFRAME: Learning content Management system in the FRAmework of METacognition

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ABSTRACT

This paper presents a discussion of the current trends in the implementation of Learning Content Management Systems (LCMSs) and provides a working definition of the features that should be provided by such systems. Thus, after discussing a new structure of Learning Objects in the framework of Metacognition to implement significant learning, it shows how an open source Content Management System based on PHP and MySQL (MD-Pro) can be transformed in a LCMS. The system discussed, LIMEFRAME, provides modules for the management of Learning Objects, for their retrieval and indexing via Metadata, and is in line with current standardization approaches with respect to Content Packaging, representation of Metadata and Learning Design. As far as some implementation issues will be solved, LIMEFRAME will be made available to the scientific community for evaluation.

Keywords

Content management systems, learning content management systems, learning objects, metacognition, MD-Pro, LIMEFRAME

INTRODUCTION

A non-rhetorical question that is still waiting for an answer is “Where is the learning in e-Learning?” (Koober, 2001). Many researchers and practitioners believe that e-Learning may be implemented by realizing instructional content, eventually broken in small pieces (LOs - Learning Objects) to be used and reused according to a LEGO-type metaphor and to be delivered over the Internet through off-the shelf Course Management Systems.

We argue that there are a number of misconceptions in the previous statement. The first is due to the idea that learning is the same as knowledge transfer. While there are undoubtedly advantages to the development of traditional learning objects, most researchers in the field have overlooked an extremely important issue: how they support learning. In the current conception, there is a strong leaning toward the notion that students should learn small amounts of discrete information at one time and slowly build a network of these information chunks. At the end of this trail, the student is supposed to be able to link together all the discrete pieces in order to understand larger concepts. “In this additive approach to education, it would be assumed that if a learner were to study maps of each region of the world independently, that learner would eventually be able to create a representation of the entire world” (Orrill, 2001). LOs built on this information delivery model fail to provide solutions for many current learning environments. The current movement in education calls for students to develop critical thinking and problem solving skills, communication skills, and know how to become a professional in their field rather than simply gain knowledge about the field itself. Shortly, the idea is to help the students learn how to learn. A step toward this goal is developing constructivist-based learning environments (Livingston, 1996). However, using LOs according to a constructivistic approach requires some rethinking of the objects and careful considerations on their use. Our primary concern is to allow the students determining whether they understand the content, whether the content is what they need, and what they still need to know for envisioning the big picture that describes the content of a LO. We believe that learning cannot occur without a strong emphasis on the pedagogical design of the material to be delivered. Furthermore, the pedagogical design must be explicitly declared in the LOs and not molded or hidden inside their content.

A second misconception is represented by the possibility of adopting Course Management Systems that have been designed to match general specifications elicited independently from the users' requirements. Thus, the general approach followed by researchers and practitioners is to adapt the learning material to the Course Management System and not vice versa. This has led to the development of sophisticated frameworks for storage and deployment of Learning Material providing a plethora of tools that in many cases are of little help both to the designers and to the learners. At the same time, little or no attention is paid to current and emerging standards on the field. This leads to the fact that only a small portion (about 30%) of the Course Management Systems reviewed by Edutools (a project based on a website created in 1997 by British Columbia's Centre for Curriculum, Technology & Transfer and Bruce Landon, <http://www.edutools.info>) claim partial compatibility with the regulations defined by the most authoritative standardization bodies on the field: the IEEE Learning Technology Standard Committee (<http://ltsc.ieee.org>), the IMS Global Learning Consortium (<http://www.imsglobal.org>), the Advanced Distributed Learning Initiative (<http://www.adlnet.org>) and the European Committee for Standardization (<http://www.cenorm.be>).

In this paper we will revert the approach: we will provide a working definition of LO that explicitly contains details regarding its Learning Design, thus providing the basis for a constructivistic approach to learning. Then, we will discuss the requirements that a Learning Content Management System (LCMS) must satisfy to implement this model. Finally, we will show how a general-purpose open source Content Management System can be transformed into a LCMS that natively implements our LO model.

LEARNING OBJECTS

In this paper we will use the term Learning Resource to address "any digital resource that can be used to support learning". This definition limits our interest to digital resources only as, for instance, figures, tables, pictures, HTML pages, presentations and so on.

A Learning Object (LO) is a digital object that complements a Learning Resource by including Metadata and an explicit representation of a Learning Design (fig. 1). In this current version, our definition of LO represents a superset of the IEEE specification discussed in (IEEE, 2002), it is conformant to the specification provided by Brennan et al. (2001), and it constitutes a variant of the IMS standard describing the approach to model the Learning Design (IMS-LD, 2003). Furthermore, the proposed structure is compliant with the IMS specification dealing with Content Packaging (IMS-CP, 2003).

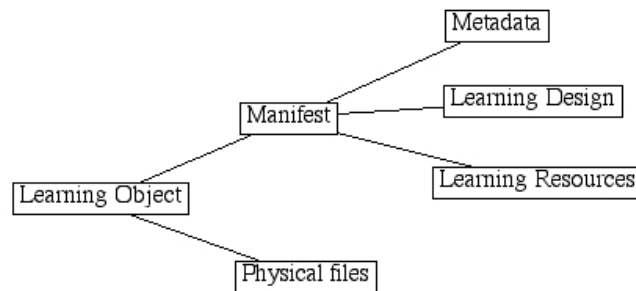


Figure 1. The Structure of a Learning Object

Metadata represent the key to resource discovery, effective use of resources and interoperability across protocol domains. According to the IEEE-LOM (2000) metadata is information about an object, be it physical or digital. Thus, metadata contain all the instructional characters of every LO along with the complete information on their physical location. The structure of Metadata inside our system has been chosen coincident with IEEE Standard.

The Learning Design is composed by a Metacognitive Framework and by some Navigational Aid that will be used to support the learner in the exploitation of the LO (fig. 2).

The metacognitive framework is originated by current research on metacognition. According to Livingston (1997) metacognition refers to high order thinking, which involves active control over the cognitive processes engaged in learning. Teaching metacognitive skills must be one of the goals of instruction, so that the learners have a bundle of strategies that will encourage significant learning (Ausubel, 1968) i.e. the process by which a learner puts new information in relation with existing knowledge.

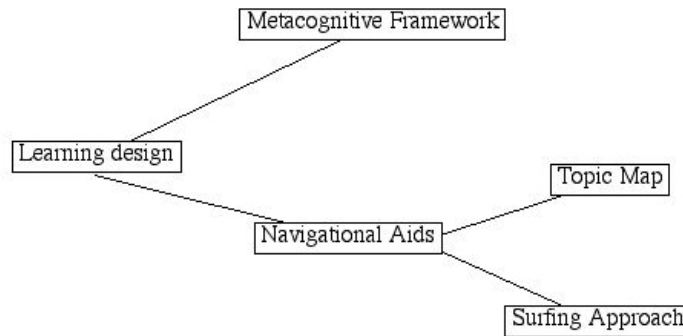


Figure 2. The structure of the Learning Design

Mechanical learning (which is used in opposition to significant learning) occurs when the learner memorizes new chunks of information without linking them with existing knowledge or when the learning material has few or no relation with previous obtained knowledge (Novak and Gowin, 1995). In this view, we define a metacognitive framework as a manifest that must be defined for every learning resource to transform it, along with some additional information, in a LO.

The Metacognitive Framework is composed by the following items: Cognitive PreRequisites, Learning Objectives, Learning Goals, Learning Expectations, Didactic Tools, Main Topics, Assessment and Tutoring Strategy (fig. 3).

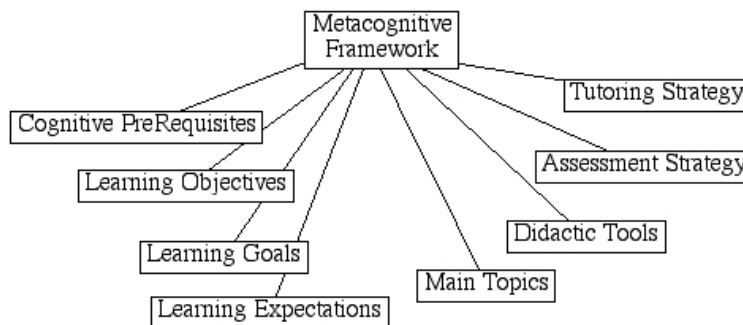


Figure 3. The structure of the Metacognitive Framework

The *Cognitive PreRequisites* describe the knowledge and the skills that the learner must possess in order to gain access to the different entry points of the Learning Resource encapsulated by the LO. In fact, if the Learning Resource is complex, as for instance a composite unit or a course (CEN/ISSS, 2000) it is possible to define different entry points of the same material according both to the background knowledge and to the skills owned by the learner. The background competence may be elicited through a placement assessment that must be referenced in the assessment strategy, and included along with the Learning Resource to complete the LO.

The *Learning Objectives* describe the purposes for which a given educational path has been designed and the targets the learner is expected to reach. This item is mandatory since it allows the learner to explicitly associate the attribute of metacognition to an educational path. In fact, the declaration of the learning objectives allows the learner to understand why, to what extent and under which perspective the topics are covered in the LO.

The *Learning Goals* describe the goals that led to the development of the LO in its current form. This item is mandatory to allow the learner to reach a better/deeper understanding of the material and to place it in a wider framework of significant learning without limiting its pure learning objectives.

Learning Objectives and Goals allow to make a distinction between the competence that the learner will be asked to show at the end of an educational path without any concern of what has happened during its progress (Objectives), from the results that the teacher/organization responsible for the learning material wants to obtain from the learning process (Goals).

The *Learning Expectations* describe the results to be attained by the learner at the end of the use of the LO, expressed in terms of cultural goals, cognitive expectations, skills and operational abilities. This item allows the learner to gather a better understanding of what she is supposed to know on completion of the educational path.

The *Main Topics* describe the arguments covered by the LO, and provide details on their organization, structure, timeline, interleaving. The explicit description of the topics covered by the LO provides the learner with continuous cognitive reinforcement and drives her throughout the educational path.

The *Didactic Tools* describe the tools that will be used inside the LO, as for instance compilers of programming languages, simulation packages, virtual-reality environments, laboratory instruments, robots and so on. The description of the styles used for the presentation of the topics covered, represents a natural add-on of the didactic tools adopted. This includes descriptive, narrative, persuasive or expositive approaches along with interactive, dialogic or sequential forms of delivery of the material.

The *Assessment Strategy* describes the policies that will be used to evaluate the attainment of the learning objectives. As a side effect, this item allows the learner to infer which results will be met by the accomplishment of the LO, thus making explicit the competence or skill gain provided by the educational path.

The *Tutoring Strategy* describes the policies that will be used to support the student in the use of the learning material. This may range from the simple provision of Frequently Asked Questions or Searchable Knowledge Bases to the description of the duties and activities that a human tutor will perform during the availability period of the LO.

Finally, the *Navigational Aids* have been included (fig. 2) to provide some indication to the learners on how to traverse the Learning Resource. The Navigational Aids include a Topic Map that allows the learner to clearly identify the point in which a given topic is discussed and the organization and structure of the topics covered, thus contributing to reduce the Lost in Hyperspace problem. The *Surfing Approach* contains a description of the ways in which the Learning Resource may be traversed according to the competence of the learner. Thus, learners with different background knowledge may adopt different approaches (as for instance depth first vs. breadth first) to traverse the Learning Resource.

Therefore, a set of HTML pages dealing with a topic, a bunch of electronic slides, an animated presentation, a questionnaire require some Metadata, an explicit discussion of the Learning Design adopted expressed in terms of Metacognitive Framework and of Navigational Aids to become a LO. What is fundamental in our approach is the assumption that a LO cannot exist before and without its Learning Design.

LEARNING CONTENT MANAGEMENT SYSTEMS

In the last few years, one of the main interests of the researchers in e-Learning has been the development of sophisticated frameworks for storage and deployment of Learning Material. Eventually, this research led to the development of powerful Electronic Learning Environments such as WebCt, Blackboard, Lotus Learning Space and many others more. Currently, it is becoming clear that an e-Learning platform should include three main components (Katzman and Caton, 2001): a Learning Content Management System (LCMS), a Learning Management System (LMS), and a Virtual Class (VC), as shown in fig. 4. While LCMS and LMS are mainly devoted to provide support for asynchronous learning, VCs are designed to allow synchronous collaboration among learners, tutors, teachers and experts. Thus, VCs provide tools for videoconferencing, voice over IP, screen and application sharing, instant messaging, provision of feedback and access to tele-laboratory instrumentation.

LMSs and LCMSs although sharing similar names and acronyms, are devoted to serve different learning needs by implementing different functions. Unfortunately, there seems to be a lack of agreement inside the e-Learning community about the features that such systems should provide. Thus, for instance, Brennan Funke & Anderson (2001) include the function of “personalized content delivery” among the main functions of a LCMS. WBT Systems (2001) and Katzman & Katon (2001) suggest that LCMSs must provide functionalities for adaptive individualized learning paths based on Learning Objects, while Shepherd (2002) includes asynchronous collaborative learning via e-mail and tools for the management of discussion groups among the features that a LCMS must provide to end-users. Moreover, according to de Leeuwe (2004) “an LCMS combines the learner administration capabilities of an LMS with the content creation and storage capabilities of a Content Management System”. This only serves to further confuse the e-Learning community. Hall (2001) reports “understanding the difference [between LMS and LCMS] can be very confusing” because most of the LCMS systems analyzed (81%) include built-in LMS functionalities. Furthermore, while 100% of the LCMS systems list themselves as being interoperable with third-party learning management systems, half of them only have actually performed interoperability tests with leading LMS products.

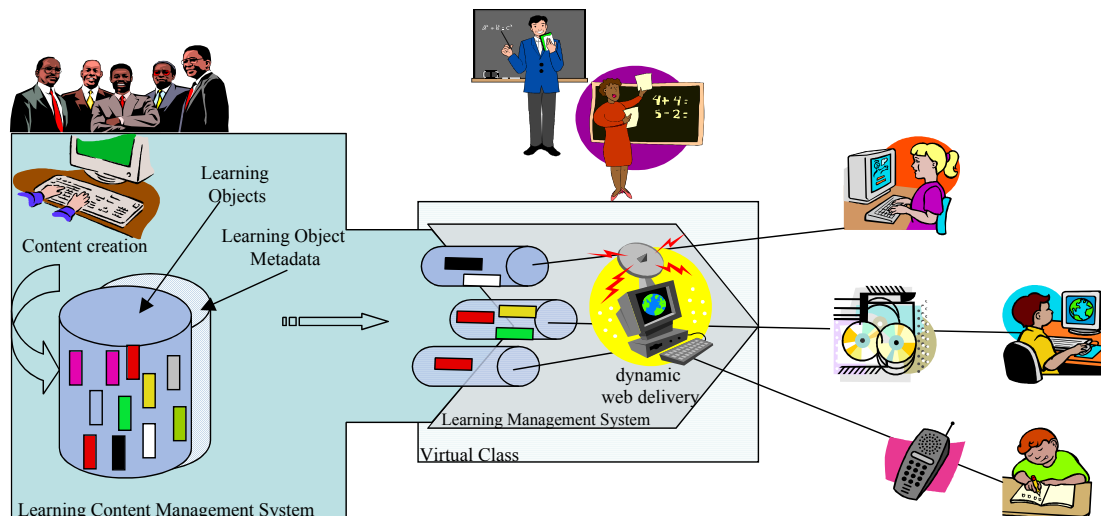


Figure 4. e-Learning platform

In the following, we will provide some working definitions of both LCMSs and LMSs. The primary goal of a LCMS is to store, maintain, index and publish content in the form of LOs that will be delivered by the LMS to the right learner at the right time (Brennan et al, 2001). Note that in this context, we will consider instructional designers and content authors as the target users of the LCMS, while learners and training managers will be the main users of both LMSs and Virtual Classes. Thus, LMSs are designed to support the learning process by keeping track of learners' progress and performance across all types of training activities. Typical features of a LMS are: registration of learners; scheduling of courses; delivery of learning material; tracking and reporting the progress of any single learner; allowing communication by chat, discussion boards, e-mail; assessment of competency, learning styles and learners commitment. In the rest of this paper we will focus our attention on LCMSs only. According to the definition and to the structure of a LO, as discussed above, a LCMS must satisfy the following requirements.

Content Creation

A key benefit of LCMSs is the capability for knowledge experts--with little or no programming experience--to author knowledge content quickly, without the assistance of third-party suppliers or information technology resources. A strong LCMS offers easy-to-use, automated authoring applications embedded in the system, including a WYSIWIG editor that eliminates the need for HTML knowledge.

At the front of a LCMS there is an easy-to-use authoring environment designed to work as a common word processor. This provides a non-technical way of creating new pages or updating content, without having to know the HTML language. A typical LCMS also allows the structure management of the site that is where the pages go, and how they are linked together. Many systems even offer simple drag-and-drop restructuring of the site, without breaking any links. Almost all LCMSs now provide a web-based authoring environment, able to further simplify implementation that allows content updating to be done remotely. This authoring tool is the key to the success of the LCMS: by providing a simple mechanism for maintaining the site, authoring can be devolved out into the content itself. The application automates authoring by providing authors with templates for creating skeletons of LOs at different levels of granularity (CEN/ISSS, 2000) as for instance: atoms, content units, composite units, courses, questions, tests, glossaries and syllabi. For each level of granularity, templates of Learning Design and of Metadata, requiring no coding knowledge, must be provided.

Most organizations maintain a body of proprietary knowledge and learning content in a wide variety of file formats. The ability to rapidly re-purpose content for online use can accelerate deployment times, therefore, the LCMS must offer easy-to-use conversion tools.

Every piece of knowledge within the LCMS must be stored as a reusable LO that can be kept as a resource for content designers within the LCMS, or delivered as a stand-alone object. This enables organizations to gain leverage and consistency of knowledge, while reducing redundant and contradictory knowledge across the enterprise.

Content Management

Once content has been created, it is saved into a central repository. All the content of the site, along with any supporting detail, is stored in such repository that allows a range of useful features to be provided by the LCMS:

- keeping track of all version of a page, and who changed what and when;
- ensuring that each user can only change the section of the site he/she is responsible for;
- integration with existing information sources and IT systems.

Most importantly, the LCMS provides a range of workflow capabilities to track the evolution of a document from the creation by the author, to the approval of the editor to its publishing by the central web team. At each step, the LCMS manages the status of the page, notifying the people involved and escalating jobs as required. In this way, the workflow capabilities allow more authors to be involved in the management of the site, while maintaining strict control over the quality, accuracy and consistency of the information. Thus, for instance, Instructional designers would create either new LOs targeting specific performance goals, or new courses by assembling already created LOs. Editors would view the submitted LOs and either approve or reject them. If approved, the LOs would be made available to all to use, otherwise they would be sent back for revision. LOs that have outlived their usefulness would either be backed up and archived, or just deleted from the repository.

Content Publishing

Once the final content is in the repository, it can be published out to the web site. LCMSs boast powerful publishing engines that allow the appearance and page layout of the site to be applied automatically during publishing. It may also allow the same content to be published to multiple sites. The LCMS lets also the graphic designers and web developers specify the appearance that is applied by the system. These publishing capabilities enforce page consistency across the entire site, and enable a very high standard of appearance. This also allows the authors to concentrate on writing the content, by leaving the look of the site entirely to the LCMS.

Due to the proprietary nature of content within an LCMS, the system must contain robust security and encryption mechanisms to protect content and user data. The LCMS must maintain a secure set of user privileges, which determine permission levels that users need to control, manage, and update content.

Content Presentation

The LCMS can also provide a number of features to enhance the quality and effectiveness of the site itself. These features are usually carried out by “modules” representing add-ons to the core LCMS, sometimes integrated as part of the base system, and can vary greatly from one system to another.

The presentation layer also makes it easy to support multiple browsers, or users with accessibility issues. The LCMS can be used to make the site dynamic and interactive, thereby enhancing the impact over the users, and even if the content providers are not creative or artistically challenged, there are a plenty of resources around to help them. They come in the form of templates and themes designed by more creative minds, and can be downloaded and added to the site, giving a complete makeover to it. Some of the best LCMSs even allow the registered user to pick up and choose the “skin” or theme of the site. Sometimes this is referred to as “personalization”, and it adds an element of flexibility for both the user and the site manager. Users will be pleasantly surprised by the ability to customize their “view”, and the site manager get credit for setting up an environment where users have more control, without breaking or reprogramming the structure of the site.

LIMEFRAME: IMPLEMENTING A LCMS BY TAILORING A CMS

Currently, a wide number of LCMSs is available on the market. According to a research project by Brandon-Hall (2003), which spanned over a six-month period, over fifty companies offering products that allow content reuse and delivery of granular modules of instruction, were identified. Similar results are reported by EduTools, which provides a review of sixty-three Course Management Systems. Only seventeen out of sixty-three belong to the category of open source software. From a comparison of those systems, we found out that only LON CAPA 1.1 (<http://www.lon-capa.org/>) provides some facility for Content Sharing/Reuse. Furthermore, only ATutor 1.3 (<http://www.atutor.ca>) and Jones e-education V2003 (<http://www.jonesknowledge.com>) provide some compliance with the IMS Content Packaging Specification, while the only platform that reports compliance with the Cancore Learning Resource Metadata Application Profile - which is synchronized with the IEEE (2002) standard - is Bazaar 7 (<http://klaatu.pc.athabascau.ca>).

Therefore, having in mind the idea of experimenting our model of LO via an open source LCMS in the perspective of free dissemination of our experience and in the light of respecting the current standardization guidelines, we decided to build our

own LCMS based on a general purpose CMS. Starting from the key requirements discussed in the previous section, we reviewed many different platforms and then we decided to adopt MD-Pro (2003) a CMS maintained by an international community of programmers devoted to the development of high quality open source software. It is a direct evolution of two successful open source CMSs, PostNuke and eNvolution, is coded in PHP, a wide used script languages for Web applications, and stores contents in a MySQL database, one of the most popular open source DBMS. It is based on a “core system” with modules for all the basic CMS functionalities (creation, management publishing and presentation of content), and has a very powerful “theme engine” *AutoTheme*, to define the “skin” of the site. Adding more modules, selected from a large collection of third party free components, can extend its basic functionalities. The development of “ad hoc” modules to satisfy specific requirements is easy, due to the characteristics of the PHP language used for coding, and to the clean interface between the modules and the core system. MD-Pro appears to satisfy most of our key requirements, thus allowing a CMS to be used for a LCMS implementation. In the rest of this section we will discuss how we accomplished this task: the resulting system, being named LIMEFRAME.

First of all, a layout has been defined so that the content page is divided in two sections: the former on the left of the user, listing the LOs organized in topics and sub-topics along with modules for text-searching and for logging-in, and a central section containing the material associated with each learning object (fig.5). On the rightmost part of the central section we have implemented a section containing contextual menus displayed in red which allow to simplify the navigation by showing the content units composing the LO. The interface to the system has been implemented both in Italian and in English.

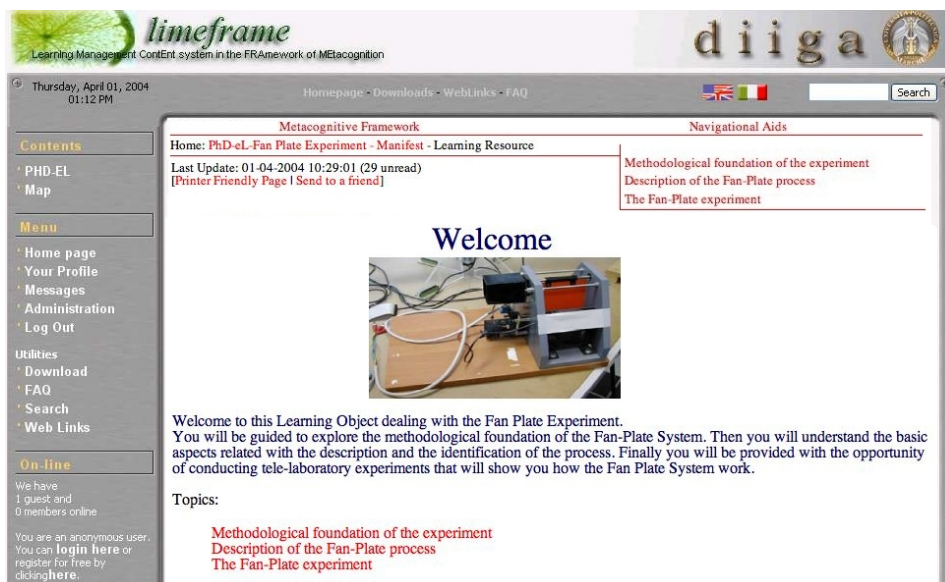


Figure 5. A screen shot of LIMEFRAME

Two links connecting to the Topic Map, as required by the Navigational Aids of the Learning Design, and to the Metacognitive Framework are displayed in the topmost part of every page of each LO hosted by LIMEFRAME (in red in fig. 5). Both the above-mentioned links and the contextual menu appearing in the rightmost part of the content window have been implemented by modifying the PHP code of the Content Express module.

One of the first issues that we had to solve was to decide how to implement a LO according to the structure discussed in section 2. We implemented each of the elements composing the manifest of a LO (i.e. Metadata, Learning Design and Resources) as a content page (fig. 6). A content page may contain both data and links to other sub-content pages, thus allowing to re-construct the tree structure of the LO in an easy and simple way.

Each content page is created via the Content Express Module of MD-Pro, which has been modified in order to show in the rightmost part of the window the links to the sub pages composing the Learning Resource.

A module named LOH (Learning Object Handler) has been implemented and is currently working, so that any time an author wishes to create a LO, an empty template is automatically created.

Another module named PFH (Physical Files Handler) allows the author to assemble all the content pages belonging to a LO in a zipped file that can be downloaded for further use outside the LCMS. The file generated is compliant with the IMS

Content Packaging Specification (IMSCP, 2003). This choice ensures the portability of the learning material over other platforms.

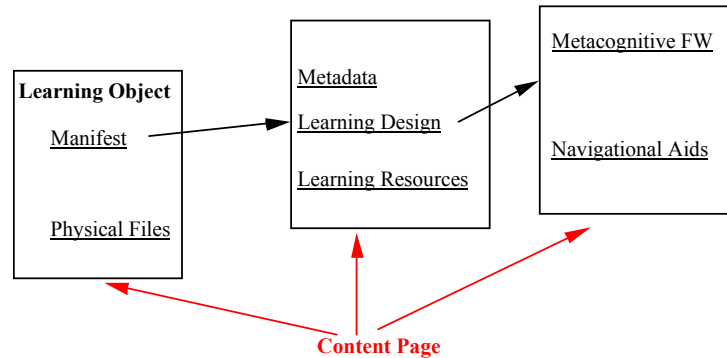


Figure 6. Our approach to LO implementation

The metadata, expressed according the LOM specifications (IEEE, 2002) have been implemented, for the time being, as content pages. A background database storing the metadata has not been implemented, yet. Thus it is possible to make text searches among the metadata of all the LO hosted by LIMEFRAME, but it is not possible to create specific queries allowing to optimize the search process.

FINAL REMARKS AND HINTS FOR FURTHER WORK

In this paper we discussed our approach to the development of a Learning Content Management System, by adopting MD-Pro an open source CMS that can support the implementation of LOs in the framework of Metacognition. A number of issues both conceptual and of implementation nature must be solved, yet.

A LCMS must be able to work at two different levels of granularity: at the level of LO and at the level of groups of LO clustered together according to a user-defined criteria. In fact, since reuse is one of the mandatory requirements for the management of knowledge, one possible scenario depicts the instructional designer searching the Metadata Data Base for LOs according to some specified criterion, selecting a sub-list of the returned LOs and clustering them in a new object that will augment the knowledge hosted by the LCMS. A point that still needs some conceptual thinking is how the manifest (fig. 1) of the newly created LO will be revised. In this perspective, the implementation of the Metadata DB using MySQL, and the creation of PHP procedures for the handling of the database represents a mandatory goal for transforming LIMEFRAME in a full functional LCMS.

Moreover, assessment is considered to play a central role in the educational process. Thus, it is very important to implement the modules that allow an easy management of questions and tests by the instructional designer. Currently, we are developing a Question Management Module that will provide a friendly interface for the creation of closed-answer question and for their organization in tests, in the realm of current standardization initiatives (IMS-QTI, 2000).

Finally, one of the advantages of adopting a CMS resides in the ability to implement all the modules needed to provide the features for creating a LMS and a VC that in the long term will interface LIMEFRAME, in order to provide a complete e-Learning platform.

As far as some of these missing functionalities will be implemented, a beta version of LIMEFRAME will be made available to the scientific community for evaluation.

ACKNOWLEDGMENTS

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REFERENCES

1. Ausubel D.P., (1968). Educational psychology: a cognitive view, New York, Holt, Rinehart & Winston.
2. Brennan M., Funke S., Anderson C. (2001). The Learning Content Management System. A New e-Learning Market Segment Emerges. An IDC White paper. IDC Framington, MA, USA.
3. Browning P., Lowndes M. (2001). Content Management Systems. JISC Techwatch report TSW 01-02.2001. http://www.jisc.ac.uk/index.cfm?name=techwatch_report_0102
4. CEN/ISSS (2000). A Standardization Work Programme for "Learning and Training Technologies & Educational Multimedia Software". CWA, CEN/ISSS WS/LT Learning Technologies Workshop.
5. Chapman, B. (2003). LCMS Report: Comparative Analysis of Enterprise Learning Content Management Systems, Brandon-Hall.com.
6. de Leeuwe, M. (2004). What is an L(C)MS?. E-learningSite.com. <http://www.e-learningSite.com/lmslcms/whatlms.htm>
7. Hall, B. (2001). Learning Management Systems and Learning Content Management Systems Demystified, Brandon-Hall.com, http://www.brandonhall.com/public/resources/lms_lcms/
8. IEEE-LOM (2002). Standard for Learning Object Metadata - 1484.12.1. IEEE Piscataway, NJ, USA.
9. IMS-CP (2003). IMS Content Packaging Specification, Best Practice and Implementation Guide, Binding Document, Schemas. IMS Global Learning Consortium, Inc.
10. IMS-LD (2003). IMS Learning Design. Information Model, Best Practice and Implementation Guide, Binding Document, Schemas. IMS Global Learning Consortium, Inc.
11. IMS-QTI (2000) - IMS Question & Test Interoperability Specification: A Review. A QTI White Paper from IMS. IMS Global Learning Consortium, Inc.
12. Katzman J., Caton J. (2001). Evaluating Learning Content Management Systems (LCMS). Establishing Criteria for comparison. Peer3 White Paper. Carlsbad, CA, USA.
13. Koolen R. (2001). Learning Content Management Systems - The second way of e-Learning. A Knowledge Mechanics White Paper. Knowledge Mechanics, Grand Rapids, Michigan, USA.
14. Lennox, D. (2001). Managing Knowledge with Learning Objects. WBT Systems White Paper.
15. Livingston J. A., (1996), Effects of metacognitive instruction on strategy use of college students, unpublished manuscript, State University of New York of Buffalo. . <http://www.gse.buffalo.edu/fas/shuell/cep564/Metacog.htm>
16. Md-Pro (2003). <http://www.maxdev.com>
17. Novak J.D., Gowin D.B. (1995). Learning how to learn, Cambridge University Press, New York.
18. Orrill, C. H. (2001). Learning Objects to Support Inquiry-Based, Online Learning. In D. A.Wiley (Ed.). The instructional use of learning objects. Bloomington, IN: Association for Educational Communications and Technology
19. Shepherd C. (2002). Making the case for content. <http://www.fastrak-consulting.co.uk/tactix/Features/lcms.htm>