

# INTEGRATED SOLUTION FOR LEARNING CONTENT MANAGEMENT SYSTEMS DEVELOPMENT

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## ABSTRACT

The problem how to develop custom Learning Content Management Systems (LCMS), integrating existing (mostly open source) software components and taking into account specific local needs, is discussed widely in the literature [1, 9, 10]. The availability of huge number of such components and tools further complicates this process. Main goal of this paper is to present a possible solution of above stated problem. For this purpose a special method for LCMS development in the form of Learning Object Repositories (LOR) was developed. The method is based on the idea of choosing and integrating from existing open source tools. It is a systematic process of software development of an Open System Architecture, by including at each next stage appropriate software components, satisfying well defined in advance specifications and standards. stages of development process are listed and developed application is discussed and presented. The proposed method is illustrated by one practical example of LCMS development. This example LCMS was at the end evaluated, in order to validate the approach and method proposed and described in this paper.

## KEY WORDS

LCMS, LOR, Learning Object (LO), ontology, Unified Modelling Language (UML), eXtensible Mark-up Language (XML), integrated solution

## 1. Introduction

Influence of education, ICT and educational organization We first start to analyze the influence of education, ICT and educational organization requirements and expectation, on the process of learning systems design and development. Then we identify the main stages in the LCMS development process. We present one approach for integration of various software tools in an open system architecture. On the base of this approach we propose a method for development of LCMS in the form of LOR. We give criteria for selection of the most appropriate tools for learning system implementation at every stage of it's development. The proposed method is further experimented and demonstrated on a real life example. A prototype of LCMS in the form of LOR is created in the field of e-learning. Exemplary reusable learning content in the form of LOs is created and used to test the system effectiveness. For each LO the corresponding metadata

description is created in order to test the system. Criteria for effective multimedia learning content development are presented and used to test the system usability. Other tests for evaluation of the quality of the learning system developed are applied, and main results are presented and discussed.

## 2. Development strategies and development cycle phases

Three most important components (ICT, education, and institutions) determine requirements to the process of design and development of learning systems. Accepted form of education and organizational expectations define basic characteristics of well designed and developed learning system. The forms of education and ICT capabilities determine and encourage development of new tools to be integrated in the education. Institutional needs and new ICT developments cause the appearance of new models. An example vision about the links between system development, information society requirements, advanced forms of education and learning systems that support them is presented on the following Fig. 1:

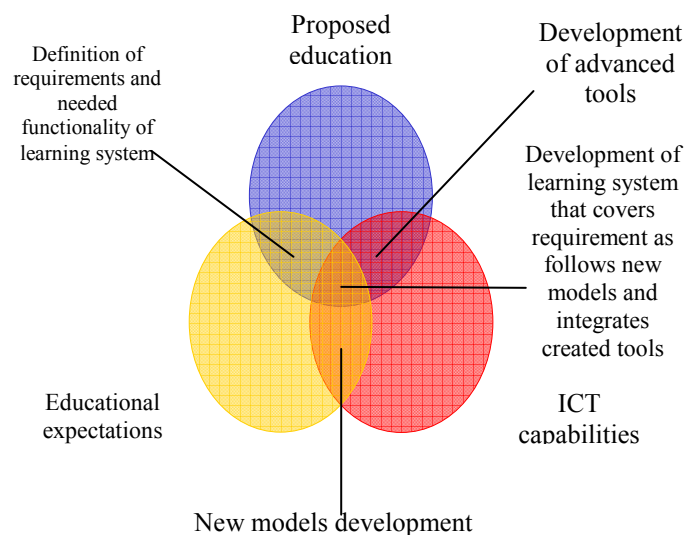


Fig. 1: Intersection of educational organizations expectation, ICT capabilities and characteristics of proposed education

## 3. Open system architecture

Development of extensible and compatible with other systems learning system is critical for effective education. For this reason selection of appropriate architecture is basic problem in the modeling and design stage of the development process. Architecture is very important component for each system that should be developed. In order to achieve both flexibility and compatibility, it is natural to use open system architecture for the development of LCMS.

We will show how to use this open system architecture for LCMS development, by elaborating in more details the proposed method in the following chapters. At the end we will present an example implementation of the proposed method.

#### 4. Integrated model for development and exchange of digital multimedia reusable learning content through learning system developed as Learning Object Repository

The entire process of design, development, implementation and testing of learning system is quite complex and continued process. There are many stages, steps, activities and selections according to defined set of criteria that should be implemented. We try to bring more order in this process, by presenting a model for design and development of high quality, flexible and reusable learning content, by using specific learning content management system, designed and developed as Learning Objects Repository (LOR) (Fig. 2).

We first start to explain this new model by dividing the main stages of the LCMS development - analysis, design, development and evaluation - in the form of more simple and easy executable activities. The first stage (analysis) should be implemented as a sequence of 4 basic activities - learning types analysis, learning systems types overview, analysis of advanced technologies capabilities for integration in education, and analysis of most appropriate e-learning standard. The second stage (design) includes the following four steps: creation of extended learner's profile described in details in [9], development of abstract model of chosen learning system type, implementation of meta-data integration model, and application of proposed methodology for ontology development. The third stage (development) is composed by two steps: development of a domain ontology (following well defined principles and rules, see [12]), and development of LCMS prototype as LOR (by following an abstract model created in advance). This abstract model can be used later on, in order to test the effectiveness of the described method. During the final fourth stage (evaluation), the validation of the developed learning system and evaluation of the created learning content is conducted, by performing the measurement of the quality of the learning content, its interactivity, effectiveness of the developed system, and its compatibility with others systems and existing standards.

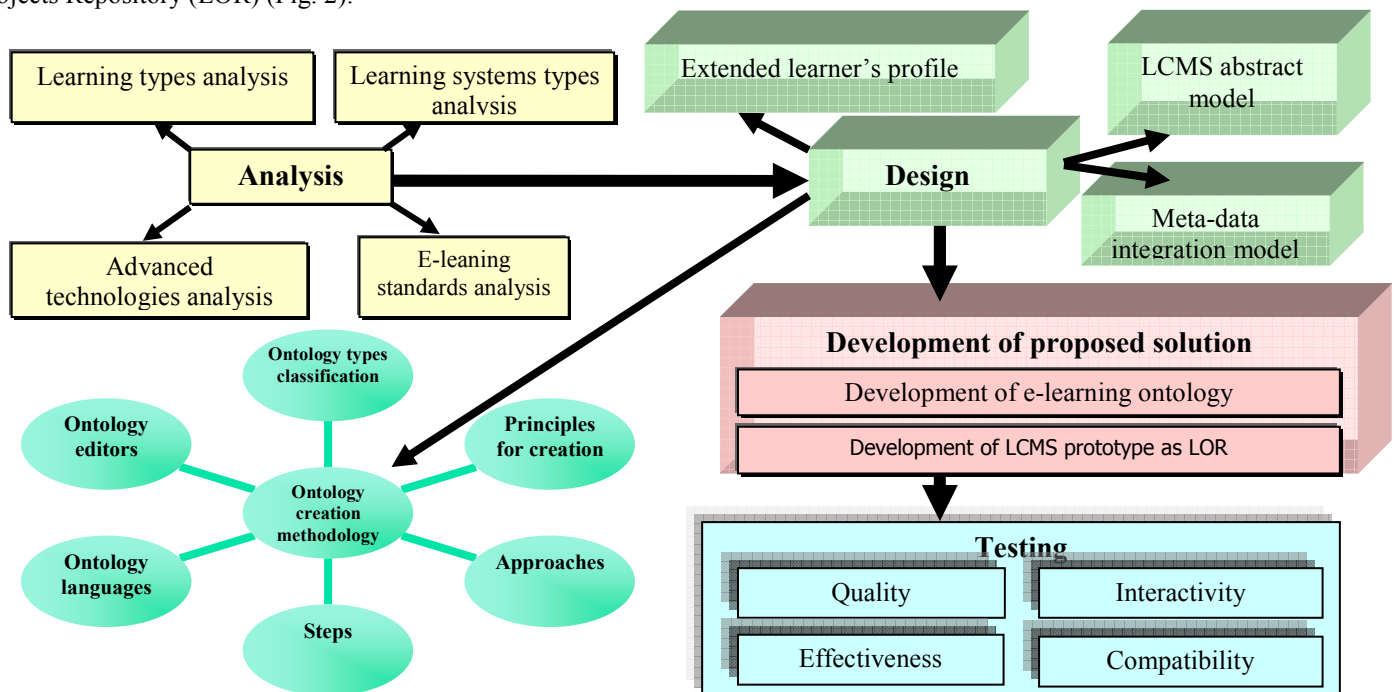
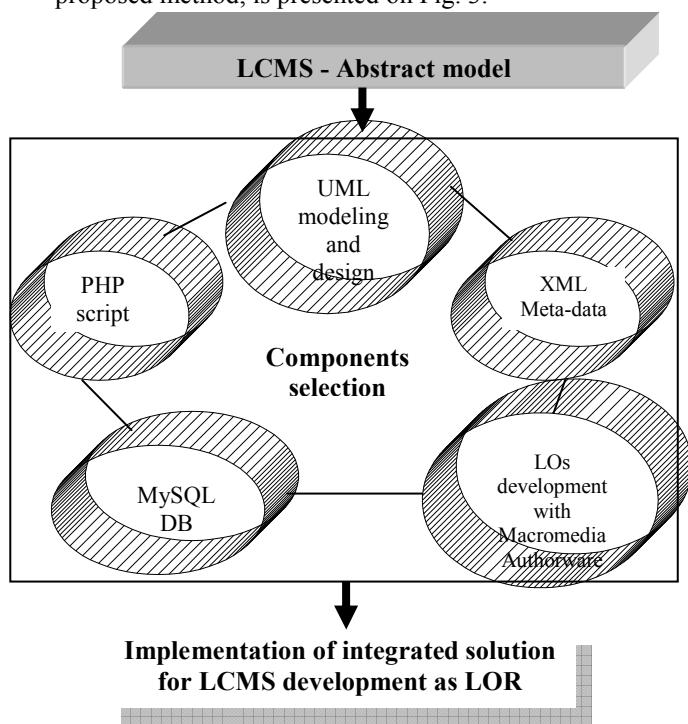


Fig. 2: Integrated model for development and exchange of digital multimedia reusable learning content through the use of learning content management systems developed as Learning Objects Repositories

For the creation of the Learning system design, we propose to use the Unified Modeling Language (UML) [14] as a tool for learning system development process planning. Various tools and software programs could be used for the development of UML diagrams that represent the main view about learning system architecture and functionality. For the definition of main functions that the system to be developed should provide, the following well known equation (proposed by Nichani, M.) is used: LCMS = LMS + CMS [RLOs] [8] .

### Elements of software system

Most important element of each learning content management system is the database that stores users' data and learning resources, scripting language that connects database with the developed user interfaces, and tools that are used for learning content development. Connections among them and transition between abstract model, components selection, and implementation of the learning content management system, following the proposed method, is presented on Fig. 3.



**Fig. 3: Components of LCMS**

We propose to use UML for the modeling of the main functions of the learning content management system. Various approaches for Learning Objects (LOs) creation are possible, like the use of specialized authoring tools, combined with the capabilities for storage the LOs itself and their corresponding metadata in databases (like MySQL), and access to them by using various scripting languages, like eXtensible Markup Language (XML) [13] and PHP [15].

## 5. Implementation of proposed solution

In the following chapters we describe an example implementation of LCMS as LOR in the field of E-Learning. We give some additional guidelines in order to elaborate the proposed method in more details, and to make it's further implementation as easy as possible.

Having in mind the lack of space, we will concentrate our description on the phases and steps regarding Database and scripting language selection, as well as domain ontology development.

### Database and Script language selection

Many popular solutions for dynamic systems development have been researched, and one particular solution was selected for the learning system code generation – the combination of the PHP scripting language and the open source database MySQL [16].

The code of application was developed on the base of the solution presented in [7], and was further modified in order to provide some important systems features arising from the system requirements.

### Ontology development

For the development of the domain ontology, containing the most important knowledge from the domain being taught by the system (in this particular example e-learning), we decide to use the Protégé editor [3]. It allows the knowledge about learning domain to be expressed using main concepts and relationships among them, and all they to be defined using user-friendly and intuitive interface. More details for ontology and meta-data creation can be found in [12] and [20].

## 6. Development of digital reusable interactive multimedia learning content

For the creation of appropriate learning content in the form of Learning Objects, we decide to use the LCMS “MS FrontPage” [5]. We first created the learning material in html format, and after that we use the FrontPage features for transforming the learning material in the form of re-usable learning objects, according to SCORM and IMS standards. For each of these LOs the corresponding meta-data file was created. The meta-data description includes basic characteristics for the corresponding LO like title, language, keywords, and so on. In order to provide interactivity for the learning content created, we decide to use the Macromedia Flash and Authorware [6] software tools. In order to test the learner performance we developed multimedia interactive tests. Various multimedia components were developed and used for providing different approaches for the presentation of the learning material. Detailed description of developed e-learning content are available in [11]. In order to achieve flexibility, we proposed a prototype of user menus (Fig. 4). This way users can enter the system and access different tolls, services and learning content depending on their status and rights in the system.



Fig. 4: Proposal for student menu interface

Learning system includes modules for administration of users and management of learning content. Some of these capabilities are presented on Fig.5.

Students interface allows access to the learning materials, organized in different courses. It provides access to several tools for communication like forum, e-mail, and message board. Store section contains important resources related to the education. Users may achieve help during the learning process and they can get information about available jobs. Program section gives information about basic BSc., MSc., and PhD. Programs delivered by the system. Course content is represented by ontology for the specific domain. Ontology is saved in HTML format and LOs are link to its concepts.

Administrative properties are divided in two section-developer menu and administrator menu. Administrator menu allows students and courses to be added, edited, and deleted. Developer menu provides capabilities for adding, editing, and deleting LOs.



Fig. 5: Learning content develop menu

## 7. Evaluation effectiveness and compatibility

After the development of the example LCMS, we conducted survey among specialist and students at Sofia University for the evaluation of learning system as a whole, and for the learning content quality. We asked

them to assess the various features of the prototype and the learning content, according to Millar's 7 criteria [4]. The general opinion about the system was used as a judgment about the effectiveness of the method itself. The main results of the tests are presented on Fig.6.

About 26-33 % of asked users evaluate 7 components of proposed prototype as appropriate, about 8-14 % find them very appropriate, 20-33 % have no opinion and about 19-25 % evaluate prototype components as inappropriate and 8-17 % define them as very inappropriate.

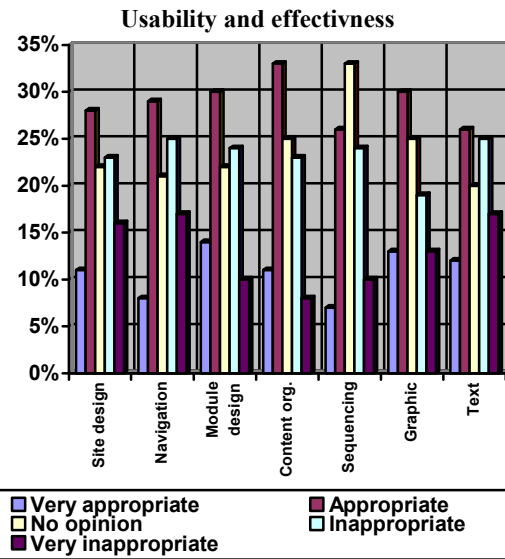


Fig. 6: Usability and effectiveness evaluation diagram

For testing the learning content and learning system several tests were implemented:

- ❑ Testing quality of developed learning materials (clearness, duration and structure of proposed lessons), described in details in [9]
- ❑ Testing effectiveness of the used multimedia elements in created LOs and interactivity of learning content (as proposed by Peter Fenrich in [10])
- ❑ E-learning standard compatibility test
- ❑ Testing effectiveness and usability of the system [4]

We give one example with the following test for measuring the effectiveness of the integrated solution (proposed by Richard Miller), which was applied to check the quality of the proposed solution [4]. Test allows features of the developed solution like navigability, site design, content organization and use of multimedia elements to be checked for proper application. Basic criteria are organized in 7 groups: site design, navigation, module design, content organization, sequencing, graphics and text and cover entire usability and effectiveness of integrated solution.

Proposed solution is compared to 3 the most common used e-learning systems at FMI, Sofia University [2]: Moodle [17], ARCADE [18], and Regional Cisco Network Academy [19].

Results are presented in Table 1.

**Table 1 Test of effectiveness and usability of integrated solution**

Characteristics	New system	Arcade	Cisco	Moodle
<b>Site design</b>				
The site has a table of contents, which includes an explanation of why the content was organized in that way.	✓	✓	✓	✓
The site has a guided tour or map that shows all major sections.	✓	✓	✓	✓
The site includes a glossary.	✓	✗	✓	✗
Unfamiliar words are highlighted and linked to the glossary.	✗	✗	✗	✗
All pages are printable, and printed pages are accurate and complete.	✗	✗	✓	✗
Accommodation is made for users who turn off graphic information displays	✗	✗	✓	✗
Page download times for the least sophisticated hardware/software configuration do not exceed 10 seconds.	✗	✗	✗	✗
Page backgrounds are white or pale pastel colors, with contrasting text colors	✓	✓	✓	✓
Textured and patterned page backgrounds are used only when they do not interfere with the clear, legible, and usable display of information.	✓	✓	✓	✓
Screens take advantage of white space to guide the viewer's eye through the display of information on the page.	✓	✓	✓	✓
Pages are displayed in such a way that those who choose to change default display	✗	✗	✓	✗
Terminology is used consistently throughout the site.	✓	✓	✓	✓
<b>Navigation</b>				
All hyperlinks work correctly.	✓	✓	✓	✓
<i>De facto</i> standard colors are used for unvisited and visited links.	✓	✓	✓	✓
Navigation options are clear and consistent.	✓	✓	✓	✓
Site navigation tells the learner what to do on each page, and where to go or what to do next.	✗	✗	✓	✗
Hyperlinks are attached to a few key words or a meaningful phrase.	✓	✓	✓	✓
Links and URLs are unambiguous, clear, and specific, and are as brief as possible.	✓	✓	✓	✓
Backward links are provided so that learners can easily return to their starting place.	✗	✗	✓	✗
<b>Module design</b>				
Learning objectives are stated in observable, measurable terms.	✓	✓	✓	✓
Each page is directly tied to a learning objective.	✓	✓	✓	✓
Each learning module has an advance organizer that includes a description of its learning outcomes and activities, a rationale for learning, and an estimate of the time needed to complete the module.	✓	✗	✓	✗
Each learning module includes a model of the organizing principles for its content.	✓	✓	✓	✗
Each learning module includes examples of acceptable performance and an explanation why	✗	✗	✓	✗
Each learning module includes an opportunity for the learner to practice performance until it is acceptable.	✗	✗	✓	✗
Each learning module includes an opportunity for the learner to demonstrate acceptable performance.	✓	✓	✓	✓
<b>Content organization</b>				
Content about the names of things and parts of things is mastered before content about the manipulation of them	✓	✓	✓	✓
Content on procedures includes both "how-to do" and "how to decide" directions.	✓	✓	✓	✓
Content on processes shows cause-effect relationships.	✓	✓	✓	✓
Content needed most often is in a prominent place.	✓	✓	✓	✓
Content critical to acceptable performance is in a prominent place.	✓	✓	✓	✓
Content that contributes to a larger understanding of the topic is in a prominent place.	✗	✓	✓	✓
"Reference" or "More About" links are used for less important content.	✗	✗	✓	✗
If learners need to explore the content and discover or create meaning	✓	✓	✓	✓
If learners need to learn names and pieces of things	✗	✓	✓	✓
If learners need to know how to do a task	✓	✓	✓	✓
If learners need to understand what happens when they do a task,	✓	✓	✓	✓
Each content piece states in action terms what the learner should do.	✓	✓	✓	✓
<b>Sequencing</b>				
Each page in a sequence clearly shows its place in the sequence.	✓	✓	✓	✓
Each page in a sequence allows navigation to other meaningful places in the sequence (e. g. start, end, previous.)	✗	✗	✓	✗
Any hyperlink that takes the learner out of the instructional program is clearly labeled	✓	✓	✓	✓
Each hyperlink is labeled clearly and consistently.	✓	✓	✓	✓
Each hyperlink uses wording that clearly identifies where it leads.	✓	✓	✓	✓
<b>Graphics</b>				
Graphics occupy minimum screen space while retaining meaningfulness.	✓	✓	✓	✓
Each graphic serves an instructional or informational need.	✓	✓	✓	✓
Graphics file sizes are minimized.	✗	✗	✓	✗
Any animation serves an instructional purpose that cannot be achieved more simply.	✓	✓	✓	✓
<b>Text</b>				
Text blocks are small enough to eliminate the need for scrolling (laptops).	✓	✓	✗	✓
Text blocks are written in minimalist style: compact, yet useful.	✓	✓	✓	✓
Fonts are restricted to two (or, at most, three) families per page.	✓	✓	✓	✓
Fonts (style, color, saturation) are easy to read in both on-screen and printed versions.	✓	✓	✓	✓
Line length is short enough that readers do not have to turn their heads side-to-side.	✗	✗	✓	✓
All text is grammatically correct.	✓	✓	✓	✓

Analysis of the results shows that proposed solution is comparable with existing e-learning systems. It satisfies the basic characteristics for effectiveness and usability and provides some advantages – attractive interface, integration of ontologies in content organization and structuring, appropriate use of multimedia and interactivity. Other important characteristics of the system are table of content, glossary, additional information resources, clear and accurate definition of learning goals and expected learning outcomes and appropriate use of text and graphics as well as clear instructions for navigation. Proposed solution allows high effective technologies to be combined and used together in order to provide efficient e-learning services and this way to provide high quality and effective education. Problems that have to be solved by adding enhanced features are related to improvement of searchable features of the system and more effective use of ontology and ontology languages capabilities.

## 8. Conclusion

Important problems in advanced e-learning and e-learning systems were identified in the paper. A method - integrated solution for development of learning systems – was presented, implemented and discussed. This method is unique, in the sense that methods for Software systems design and development exists, as well as methods for Learning Systems design, or for Learning System Evaluation. Each such method either is focusing on particular stage of the LCMS, or is stressing on the Software Engineering common problems, not on LCMS in particular. So the main result from this research is the method for the integrated LCMS development in the form of LOR. The idea for LCMS development and use as LOR was explained and applied. Various software tools with potential to be integrates in the example system were analyzed and best of them selected. Use of developed and extended models and methods was presented and discussed. Several tests for measuring the system's effectiveness and compatibility with existing e-learning standards were proposed and applied. Results were presented, shortly discussed, and some proposals for further improvement were made. Existing tools for LCMS development were presented in the paper, and the characteristics of some of them were analyzed and compared for selection of the most appropriate combination. Problems related to open system architecture and open source software, and challenges related to their use in the process of learning system implementation were discussed and possible solutions were proposed.

Future research efforts will be directed to better integration of open source software in all phases of the design and the development of learning systems, and analyzing the capabilities of existing tools for integration of new technologies in the systems that support education. Another future direction for research will be to improve the proposed models for learning systems development so

they become compatible with existing and emerging e-learning standards.

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