EVALUATION OF SCORM BASED LEARNING SYSTEM

S. Arsenovski[1], I. Kraljevski[2], M. Mihajlov[3], I. Jolevski[4]

1) Faculty of Social Sciences, AVNOJ 74a, Skopje, R. Macedonia,

2) Veterinary Institute Skopje, Lazar Pop-Trajkov 5-7, Skopje, R. Macedonia,

3) Military Academy, Vasko Karangelski bb, Skopje, R. Macedonia,

4) Faculty of Technical Sciences, St.Clement Ohridski University, ul. Ivo Lola Ribar b.b., Bitola, R. Macedonia

arsenovski@mt.net.mk, kraljivan@vetinst.ukim.edu.mk, martinmihajlov@yahoo.com, ilija.jolevski@uklo.edu.mk

Abstract: A prototype learning system with selective application of SCORM model is developed and evaluated. The prototype system consists of WEB based run-time environment and a database system. According to the recommendations of ADL initiative, the following functions are implemented in the system: users' management; learning material design; and complete learning process. To justify system functionality, courses related to information technology are implemented. In order to evaluate usability, functionality and most of all educational aspect, the ADL prototype system was available and used by students of Faculty of Veterinary Medicine in Skopje. The ADL prototype system was used for realization of the subject "Informatics" for students in the first year of studies, and a survey was conducted at the end of the course. Further work on developing and improvement on the prototype system will depend on the general progress and recommendations of ADL initiative. Interventions in the prototype system may be expected regarding the exchange of educational materials with some other ADL systems, and continuing activities will be development of the new courses, improving and updating the existed toward newer versions. The paper describes the system architecture and the tools used for its development. System functionality and developed courses are also addressed.

Keywords: SCORM, ADL, learning system, multimedia, computer science, Informatics

1 Introduction

The advantages of using computers for learning have been recognized since the early beginning of computer technology development. Historically, two different types of systems for Computer Assisted Learning are considered: Computer Based Instruction (CBI) systems and Intelligent Tutor Systems (ITS). The CBI systems provide learning by instruction repetition. Unlike CBS systems, the ITS systems contain intelligence in terms of generating instructions according to learning goals. But, both systems acknowledge design of learning resources and a learning management system (LMS) as the same process. This approach has two bottlenecks: educational resources are defined, structured and presented using different formats; and functional modules embedded in a particular learning system can not be reused by a different one in a straightforward way.

The recent accomplishments in WEB and computer technologies have provided possibility to divide LMS from learning resources. As a consequence of this approach, several organizations including the IEEE's LTCS, IMS project, Aviation industry's AICC, DoD ADL initiative, ARIADNE, GESTALT project, PROMETEUS, GEN/ISSS/LT, GEM project and many others, started their work on standardization of learning meta-data schemes, course structures and software interfaces to provide interoperability between different LMS and learning resources [1].

Advanced Distributed Learning (ADL) initiative aims to define standards for development universal learning resources. To provide interoperability, reusability and compatibility a referent Sharable Content Object Reference Model (SCORM) has been under development [2]. This model is an integrated collection of technical specifications that enable conforming WEB based learning products and learning content to interoperate.

With selective application of SCORM model, a prototype learning system is developed. According to ADL recommendations, the following functions are implemented in the system: users' management; learning material design; and all required functions one learning process to be carried out. At present, courses related to information technology are implemented. These courses were previously developed and implemented in CBI based multimedia learning system on CD ROM.

The system fulfills the basic ADL requirements, to offer learning process at any place in any time. The centre of the system is knowledge database accessed by a unified interface for all user categories. Users are divided into four categories: designer – a person who is responsible for design and implementation of teaching materials and courses; instructor – a person who is responsible for monitoring students' progress and communication with students during the learning period; student – a person who uses the system to acquire knowledge; and administrator – a person who is responsible for proper system operation.

2 Standards for WEB based learning systems

The recent accomplishments in WEB and computer technologies have provided possibility to design effective learning systems. However, as the main problem remains the standardization of WEB learning systems.

WEB based systems use two data types: 1) learning materials available in different forms and formats (text, audio, video, etc); and 2) meta-data for extensive material description. The standardization is required to provide: 1) a unique format for learning materials in terms of their definition, organization and presentation; and 2) interoperability between different LMS and learning resources which means functional systems implemented for one LMS to be reused on the same manner by different LMS. So, the standardization process has several advantages in terms of searching, evaluation, acquisition and appropriate delivery of learning materials.

One of the most important initiatives for WEB based learning systems standardization is the ADL initiative of Department of Defense (DoD) of USA. The aim of DoD was to develop a wide strategy for using learning and information technologies to modernize education and training. The initiative should also promote cooperation between government, academia and business. The ADL initiative has defined high-level requirements for learning content, such as content reusability, accessibility, durability and interoperability. To describe learning materials and their meta-data a referent information model called SCORM (Sharable Content Object Reference Model) is defined.

3 SCORM (Sharable Content Object Reference Model)

To define SCORM model, ADL initiative used recommendations of the following groups and associations IMS Global Learning Consortium Inc., Aviation Industry's CBT (Computer-based training) Committee (AICC), Alliance of Remote Industrial Authoring & Distribution Networks for Europe (ADRIANE) and Learning Technology Standards Committee – IEEE LTSC. Sharable Content Object Reference Model (SCORM) is an integrated collection of technical specifications for (1) Content Aggregation Model and (2) Run-time Environment.

The SCORM Content Aggregation Model represents a pedagogically neutral means for designers to aggregate learning resources. The model contains definitions of learning contents, recommendations for organizing and storing learning content and definitions of meta-data model. The specifications for the Run-time environment describe the architecture of the LMS. The description considers instructions for activation, communication and searching of contents in WEB environment.

3.1 Content Aggregation Model

SCORM Content Aggregation Model enables aggregation and organization of educational resources in a unique structure for the purpose of delivering a desired learning experience. The term educational resource denotes any information necessary to gain learning experience. The process of creating and delivering learning experiences involves the creation, discovery and gathering together, or aggregation of simple learning elements into more complex learning resources and then organizing the resources into a predefined sequence of delivery. Therefore, the SCORM Content Aggregation Model requires following components to be designed: **Content Model** or components of a learning experience; **Meta-data** or the elements necessary to describe instances of the content model components; and **Content Packaging** with **Content Structure** to describe the intended behavior of a learning experience and **Content Packaging** to describe packaging of learning resources for movement between different environments.

3.1.1 SCORM Content model

SCORM content model describes SCORM components necessary for building educational experience from reusable educational resources. Content aggregation model also determines the reuse of modular educational resources when organizing more complex educational structures. SCORM content model considers following components: 1) Assets; 2) Sharable content objects - SCO and 3) Content aggregation packages.

The most basic learning form according SCORM model is composed of **Assets**. The assets are electronic representations of media, text, images, sound, web pages, assessment objects or other pieces of data. A Sharable Content Object (SCO) represents a collection of one or more assets together with a specific launchable asset which enables communication between the object and SCORM Run-Time Environment. A Content aggregation package is a map that is used to aggregate learning resources into a cohesive unit of instructions. It defines the content structure that provides the mechanisms for defining navigation through content structure.

3.1.2 SCORM Meta-data model

The aim of SCORM meta-data model is to provide common nomenclature for describing learning resources. SCORM meta-data model is defined according to specifications suggested by IEEE LTSC Learning Object Meta-data (LOM) standards and IMS Learning Resource Meta-data XML Binding specifications [2]. IEEE specifications provide 64 meta-data elements. This number is much bigger than the number of required meta-data elements to describe SCORM based educational resources.

Generally, elements of SCORM Meta-data model are divided in nine categories: 1) The *General* category or the general information to describe the resource as a whole; 2) The *Lifecycle* category or the features related to the history and current state of this resource and those who have affected this resource during its evolution; 3) The *Meta-meta-data* category or information about the meta-data record itself; 4) The *Technical* category or the technical requirements and characteristics of the resource; 5) The *Educational* category or the educational and pedagogic characteristics of the resource; 6) The *Rights* category or the intellectual property rights and conditions of use for the resource; 7) The *Relation* category or features that define the relationship between this resource and other targeted resources; 8) The *Annotation* category or comments on the educational use of the resource and information on when and by whom the comments were created; and 9) The *Classification* category describes where this resource falls within a particular classification system.

3.1.3 Content packages

The aim of organizing educational resources in content packages is to provide standardized way for interoperability between different educational resources and learning systems. These packages also define the structure or organization and expected behavior of the educational collection. Content packages, determine 1) manifest data file to describe the course and its content, data file with course meta-data, course structure organization and the content package behavior; list of references for course resources; 2) XML binding of the SCORM model; and 3) physical organization and the way of creating learning collection archives. Content packages are expected to be used to move digital learning resources or collections of learning resources between LMS, development tools and content archives.

3.2 Run-time Environment

A goal of the SCORM Model is learning resources to be reusable and interoperable across multiple LMS. To enable this, SCORM defines how to develop Run-time environment, defining a common way to start learning resources, a common mechanism for learning resources to communicate with an LMS and a predefined language or vocabulary forming the basis of the communication. Figure 1 shows the concept of SCORM based LMS.

LMS use the Launch mechanism to start Web-based learning resources. This mechanism defines the procedures and responsibilities for the establishment of communication between the delivered learning resource and the LMS. The communication protocols are standardized through the use of a common Application Program Interface (API).

It is the responsibility of the LMS to manage the navigation through learning resources. The navigation is based on the content structure defined in a content package. LMS may adaptively determine sequencing according to the fulfillment of defined prerequisites of learning resources. The progression through learning resources may be sequential, non-sequential, user-directed, or adaptive, depending on the capabilities of the LMS.

The LMS may implement the launch in any manner and may delegate the actual launch responsibility to the client or server portion of the LMS as needed. The actual launch must be accomplished using the HTTP protocol. Ultimately, the learning resource identified by the launch location in a content package is launched and delivered to the client browser.

4 The prototype learning system

4.1 System structure

A universal prototype system for WEB based learning to provide a new tool for individual learning is designed. The system is a result of Military Academy efforts to implement novel methods in the process of individual training and education, and includes the knowledge and experience obtained through our participation in the different subgroups of NATO Training Group (NTG).

The system is based on advanced distributed learning (ADL) concepts and implements SCORM model to organize learning materials. The system consists of a WEB based LMS run-time environment and a database system. The run-time environment is a dynamic WEB application, installed on a Microsoft IIS 5.0 WEB server. For users, basic interfacing and connectivity is provided by a standard WEB browser. User interface is developed using HTML technology, while application functionality is implemented by Active Server Pages (ASP) technology. The ASP is used to render customized user interfaces and to deliver the learning data in the learning process according to meta-data in the database. Figure 1 shows the system structure and the key users.

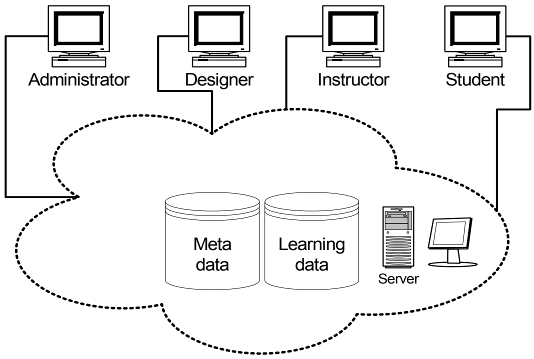

Fig. 1: System structure

4.2 Database model

Two categories data are organized in the database system. The first category considers users and courses meta-data elements, while the second includes educational materials. Both categories are organized following SCORM specifications. Because the SCORM model is cumbersome, we decided to implement all mandatory elements, and some of suggested elements.

All system data (meta-data and learning data) are stored in one unique database. In the prototype, database is developed using Microsoft Access. The figure 2 shows the database schema of the system database. To provide interoperability with similar ADL based systems, plug-in software module for course conversion into XML format is developed, too.

4.3 Organization of educational resources

The courses in the system are organized following SCORM model specifications. They are divided in three levels, courses that correspond to SCORM content packages; topics that correspond to SCO objects; and contents that correspond to assets.

Like assets in SCORM model, learning contents can be any atomic learning information, including text, pictures, video and audio clips. All text data are formatted as HTML pages and are interconnected by HTML links. To provide easier document formatting, a simple HTML editor is developed and implemented in the system. Each asset can also contain information in any different format, like audio, video, animation, etc. These materials are designed separately of the system using appropriate tools and afterwards are added to the text data by HTML links.

The learning system is centralized. That means, all educational resources are stored on the same server. This approach has two bottlenecks. The first one is limited memory space for the database. To avoid bottlenecks, the course designers must be concerned with the memory matters. The second bottleneck is the possibility of appearing system deadlock. It can be experienced during the multiple accesses to the same multimedia element.

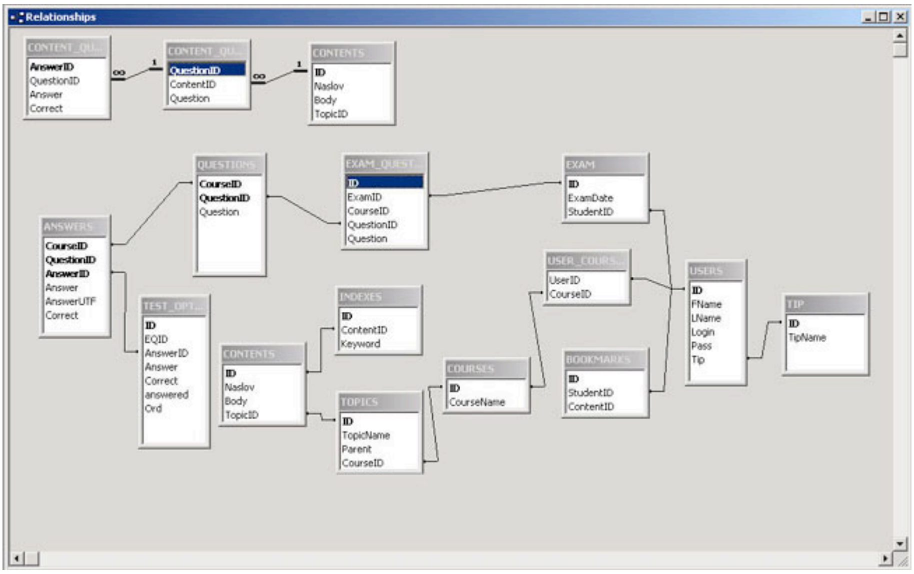

Fig. 2: System database

At the user side, the format of multimedia elements is not important if he has installed all necessary applications on his computer. To reduce the number of required applications and plug-ins, all materials in pilot courses are designed using standard formats. Therefore, each user needs only standard WEB browser, because the system does not require additional applications and plug-ins.

According to the initial design of the learning data in our system, data are enclosed and inaccessible to other LMS-s. To provide interoperability with other LMS the learning data can be exported outside the system by the software plug-in. The plug-in is the module which receives requests for SCO-s or Assets and then converts requested elements in the XML format to enable other LMS to retrieve needed learning material and its meta-data. Generated XML meta-data file contains all necessary URL for accessing the learning material through standard Internet HTTP protocol.

4.4 XML representation of content structure

As previously addressed, content structure are specifications for representing the structure of learning collections. This is relatively new approach of designing learning contents. In the past, CBT designing tools provided the means of creating course parts, as well as, how and when those parts to be presented to the learner. The shift to Internet-based technologies and the notion of building reusable learning resources has changed considerably the designing process.

Within our system there are two distinct products: the learning resources (ex. HTML pages) that are launched in the browser, and Content Structure information that is taken by the LMS and processed during run time. The structure information is separated from the content and is standardized to enable learning collections in the future to run across different SCORM based LMS environments. This information is generated by the course designers and all its data are stored in the database records with meta-data.

When a student logs in the LMS, separate process reads the meta-data of assigned courses for the specified user, and generates XML manifest file according to user data. Afterwards, XML file is executed by the LMS, generating the hierarchical tree menu at the left side of the users working environment.

The XML manifest file is compatible with the IMS Content Packaging Specifications. The data structures described by the manifest provide interoperability of Internet-based content with content creation tools, LMS-s, and run-time environments. The provided set of manifest structures are standardized and used to successfully exchange content with compatible LMS.

The XML manifest file contains three parts: **Content Hierarchy**, **Context Specific meta-data** and **Sequencing and navigation part**. Figure 3 presents general structure of SCORM based XML manifest. **Content Hierarchy** defines a tree-based representation, much like table of contents that groups learning resources into logical order. In many cases the tree represents the default order to progress through the material. The **Content Specific meta-data** is linked to the associated meta-data of the learning resource and describes its purpose, description, and name. The **Sequencing and navigation** used in our system is simple and directs the LMS during traversing through the content tree, delivering one learning resource after another. Even the general SCORM model at this stage supports only this option for traversing learning resource.

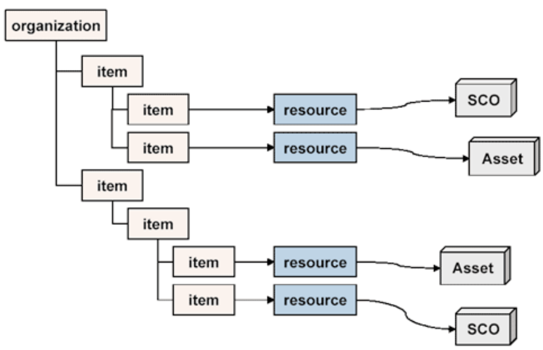

Fig. 3: Logical XML manifest structure [2]

The next example shows XML file for generating XML student menu for the course MS Windows.

```
<?xml version="1.0" encoding="windows-1251" ?>
```

```
<top type="root" value="Почеток" url="">
<topnode3 type="root" value="Windows" url="">
<node40 type="folder" value="Основни елементи" url="">
<body177 type="document" url="index.asp?id=177" value="Општо за Windows"/>
<body178 type="document" url="index.asp?id=178" value="Новитети во Windows 2000"/>
<body179 type="document" url="index.asp?id=179" value="Активирање на Win 2000"/>
<body180 type="document" url="index.asp?id=180" value="Екран на Windows "/>
<body181 type="document" url="index.asp?id=181" value="Начин на работа"/>
<body182 type="document" url="index.asp?id=182" value="Акции со глувчето"/>
<body183 type="document" url="index.asp?id=183" value="Акции со тастатурата"/>
<body184 type="document" url="index.asp?id=184" value="Активирање на апликација"/>
<body185 type="document" url="index.asp?id=185" value="Затворање на апликација"/>
<body186 type="document" url="index.asp?id=186" value="Затворање на Windows"/>
</node40>
```

4.5 User interface

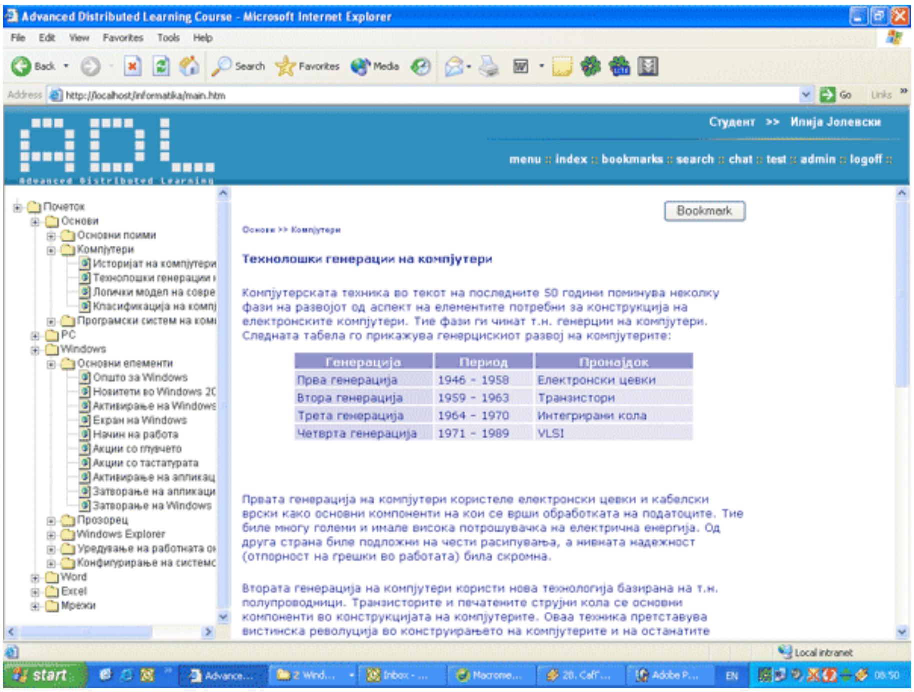

Fig. 4: System user interface

The system user interfaces are unified for all system users. That means the same logical structure of working environment is provided for all users and only contents that are presented to the users are different. Figure 4 shows the working environment logical structure.

The working environment is divided in three logical parts. The title and a toolbar are placed at the upper part. The content of each toolbar is dependent of the user and is unique for each user. Each toolbar contains one or more options: menu, index, bookmarks, search, test, chat and logout. On the left side of the page appears the working menu, which organizes all user functions in the system. The menu is SCORM-like and via XML generates the hierarchically organized menu of shortcuts. The menu structure is created for each user according to its meta-data. The right side of the page represents user's working area. In this area the system presents elements invoked from working menu.

4.6 System users

Taking into account system functionality, four different user categories are defined: 1) students; 2) instructors; 3) administrators; and 4) designers. The main task of administrators is to provide system maintenance and system functionality. Therefore, system offers them the following functions: user maintenance (inserting new users data, user classification, updating user personal data, connecting students with courses); and determination of instructors and designers for particular courses.

The users that belong to instructor category are responsible for maintenance of assessment materials and permanently monitoring of student progress. To realize their task, the system provides them with the following functions: monitoring student progress by permanent access of student assessment results and communication by chat or e-mail to provide permanent help or suggestion for students.

Students are the most important users of the system. For them the system offers: attending course lessons, assessment with tests generated by the system, browsing the learning material and communication with other users like other students or instructors.

Course designer are the users responsible to create learning resources. They, besides selection of the learning materials, make selection of the presentation style, organize and divide material into topics, subtopics and educational contents, develop tests for student's assessment, etc. All these tasks are organized like separate functions and are added to the system.

5 Courses in the prototype system

Several courses for information technology are implemented in the system. These courses are part of the system for multimedia based learning system implemented on CD ROM [3]. The system contains learning materials of the informatics course that is held at Military Academy. It contains six parts: 1) basics of informatics; 2) hardware; 3) MS Windows; 4) MS Word; 5) MS Excel; and 6) computer networks. Designed learning materials fulfill all necessary requirements for functionality and student assessment of a modern multimedia learning system (MLS).

Learning resources in the MLS contain educational elements organized in several electronic formats integrated into HTML documents [4][5][6][7][8]. LMS of the multimedia learning system is developed using Visual Basic. Figure 5 shows the architecture of the MLS. According to the figure learning resources can be:

- text files – text files are used to implement elementary educational elements of MLS. Educational content of these files is developed to provide answers to all questions concerned with simple educational experience. Each file contains problem identification, the learning goal, problem description, answer explanation, presentation of the working window for the problem and additional information to illustrate or explain the problem;
- video clips – video clips are used to explain procedures and actions necessary to perform tasks. Many of video elements provide audio explanation of presented material;
- animations – all difficult procedures and explanations about hardware components are presented to the users by animations; and

8. pictures – pictures are used to present hardware components.

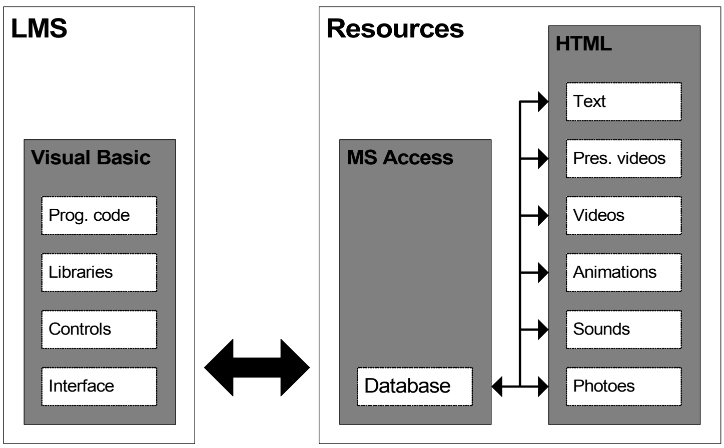

Fig. 5: Architecture of MLS

The HTML structures for resources in MLS are not unified. Several structure classes are defined for HTML documents. These classes are used to determine how the system will present the HTML document content during application run time.

The MLS provides hierarchical and sequential navigation through material. Additionally, non-linear navigation is provided by keywords and grouping contents with similar meaning. The system also provides interactivity in terms of activation and execution control of all multimedia elements.

All meta-data for learning resources are stored in database realized in MS Access. According to meta-data, LMS dynamically generates HTML documents that are delivered to the student. The same organization is kept for the ADL based prototype system.

Conversion of learning resources from the MLS to an ADL based prototype system includes interventions in the database. Additional meta-data required by SCORM specifications were added to the existing database. Learning texts are also added to the database, and the prototype LMS system reads them from the database. All other multimedia elements are not changed. They are implemented in the system only by adding necessary meta-data for their description.

6 Prototype system evaluation

In order to evaluate usability, functionality and most of all educational aspect, the ADL prototype system was available and used by students of Faculty of Veterinary Medicine in Skopje. The prototype system was used for realization of the subject "Informatics" for students in the first year of studies, at the end of the course, a survey was conducted among 67 students of 70 registered.

6.1 Conditions of the evaluation

All students (total 70) were registered in one virtual classroom, since only one instructor was available. The students were able to access to 6 courses, but they were examined only for 4 of them: Windows, Word, Excel and Computers Networks. One computer laboratory was available with 15 workstations and the system was installed and running on Windows 2000 based Web server. The students were also able to access the system from remote location via Internet anytime.

6.2 Exam

The final exam was performed by generating multichoice questions form the course contents. The students were examined on total 50 questions as following: Windows (15 questions), Word (15 questions), Excel (15 questions) and Computer Networks (5 questions).

The exam results are shown on the table:

Points	Grade	Students
0-24	5	5
25-29	6	6
30-34	7	3
35-39	8	10
40-44	9	19
45-50	10	24

ADL systems in their nature are asynchronous, with the concept to learn "anywhere and any time". Despite that it seems that the experiment was conducted in synchronous manner. The reason of that is the organization of the course as a part of regular studies. On the beginning of the course only two classes were performed on traditional way by the instructor in order to demonstrate the use of the ADL prototype system and provisional time schedule is proposed to moderate the dynamics of learning process. Anything else was matter of choice, the students were not forced in any way to attend the classes or any special additional work or tests were given. The instructor was in contact in the virtual classroom and by SCO tests with the students that needed any additional help.

6.3 System functionality

From the survey results it can be noticed that the group is heterogenous regarding previous education. Most of the students (78%) graduate on economics, medicine or electro technical high schools. As a result of high schools education projects according PHARE programs these schools were very well equipped with information technology equipment (computers, LCDs). For more than 79% of the students, this was their first experience working with electronic learning systems. They were able to use it every day (80%), and it was available and easy to use (87%). 25% of the students tried to access the system from remote location by academic network – MARNET, 82% have experienced no technical problems, 76% were able to watch animations and video materials and 61% were not use the virtual classroom for communication with other students and instructor (they used the system in real classroom – computer laboratory). They are willing to take participation in similarly organized course (91%), and between traditionally and ADL system they will choose the second one (78%). 81% of the student grade usefulness of this method of learning - excellent and very good. Most of the students (77%) were aware that instructor is monitoring their progress, but that does not disturb them.

6.4 Educational value of the courses

Students were requested to grade their knowledge before and after finishing the courses. 9% of the students grade their knowledge with “excellent” before, and 32% after finishing the courses. Similar increase of the percentage was observed with student that self grade with “very good” and “good”. These results indicate to high educational value of the courses. 74% stated that their achieved knowledge will not be better if the courses would be conducted on traditional way. 67% were satisfied with the available time terms for accessing the system in the computer laboratory, and 31% of the students requested more time terms. Students were satisfied from the organization and the placement of the elements in the system (91%), they were using all possibilities offered by the system, and most of them SCO tests. Contents of the courses graded with “excellent” by at least 50%, 85% of the students think that more images and animated sequences are necessary, and 59% that the video sequences need audio comment too.

6.5 Exam results

The positive attitude which the students build in the respect of the subject and the way they are learning is obvious it from the survey. Satisfaction is not only a consequence of being involved in something new, but also students realize that they have aquired and posses quality knowlege confirmed by the results from the exam. 64% of the students achived ”excelent” grade (9 and 10), and 15% ”very good” grade.

7 Conclusion

SCORM specifications are detailed and therefore cumbersome for implementation. Additionally, SCORM model is not fully developed, in order to be compatible with the future versions of SCORM model, the system should completely fulfill the standards. Prototype system is based on SCORM and ADL principles.

Developed prototype can be easily applied for a wide range educational topic. It also provides easy development process of learning material that is much similar to entering text by a simple text editor. All multimedia elements are developed independently of the system which enables flexibility in selection of tools for their development.

The system has advantage because the end user is not concerned with resources format if he has installed a standard WEB browser. He does not need any other application to attend some course. Assessment of the student progress is continuous process with online chat and e-mail communication. The system offers assessment of students by tests, that are permanently enabled to students and which are also permanently monitored by instructors. The free access to materials, possibility the students to create alone their learning schedules, and the big number of interactions, prove that the system even with such cumbersome hierarchical organization of learning resources would improve learning process of any student.

Acknowledged educability of implemented courses previously developed like CBI based system is kept in the prototype system, too. The advantages obtained with this new approach are accessibility, increased interactivity, and permanent communication and collaboration between students and instructors.

After finishing development of the system and implementation of the courses, the prototype system was installed and applied for experimental use on Faculty of Veterinary Medicine in Skopje. Students form the first year of studies used it for learning and preparation the exam on the subject “Informatics”, containing 4 of 6 courses implemented in the system.

After finishing the semester, students were requested to anonymously answer to 30 survey questions related to system functionality and educational value of the courses. The results undoubtedly confirm the successfulness of the system and the courses regarding the functionality and the educational value.

Further work on developing and improvement on the prototype will depend on the general progress and the recommendations of the ADL initiative. Interventions in the prototype system may be expected in the meaning of exchange of educational materials with some another system, as well as development of the new courses, improving and updating the existed ones toward newer versions are activities that will be lasted in continuity.

8 References

1. Anido-Rifón, M. J. Fernández-Iglesias, M. Llamas-Nistal, M. Caeiro-Rodríguez, J. Santos-Gago, J. S. Rodríguez-estévez, *A Component Model for Standardized Web-based education*, ACM Journal of Educational Resources in Computing, vol. 1, no. 2, summer 2001, article #1.
2. www.adlnet.org
3. Sime Arsenovski, *Multimedia Learning Systems*, Master Theses, 2001, Skopje
4. Skinner, B. F. (1968), *The Technology of Teaching*. New York: Meredith Corporation.
5. Piaget, J. (1970), *The Science of Education and the Psychology of the Child*,NY: Grossman.
6. Tapscott, D. (1998), *Growing Up Digital: The Rise of the Net Generation*. New York: Mc Graw Hill.
7. Gagné, R., Briggs, L. and Wager, W. (1992). *Principles of Instructional Design* (4th Ed.). Fort Worth, TX: HBJ College Publishers.
8. Boyle T. and Davies M. (1996) *Hypermedia environments for learning to program*. In P. Brusilovsky, P. Kommers and N. Streitz (eds) Multimedia, hypermedia and virtual reality. LNCS 1077. Springer.