INTERNATIONAL JOURNAL OF COMPUTERS COMMUNICATIONS & CONTROL
ISSN 1841-9836, 12(2):227-237, April 2017.

The Model for Learning Objects Design Based on Semantic Technologies

D. Gudoniene, R. Maskeliunas, D. Rutkauskiene

Daina Gudoniene*, Rytis Maskeliunas,
Danguole Rutkauskiene
Kaunas University of Technology
Studentu str. 50, Kaunas, 51392, Lithuania
*Corresponding author: daina.gudoniene@ktu.lt
rytis.maskeliunas@ktu.lt, danguole.rutkauskiene@ktu.lt

Abstract: The paper presents a comparison of state of the art methods and techniques on implementation of learning objects (LO) in the field of information and communication technologies (ICT) using semantic web services for e-learning. The web can serve as a perfect technological environment for individualized learning which is often based on interactive learning objects. This allows learners to be uniquely identified, content to be specifically personalized, and, as a result, a learner's progress can be monitored, supported, and assessed. While a range of technological solutions for the development of integrated e-learning environments already exists, the most appropriate solutions require further improvement on implementation of novel learning objects, unification of standardization and integration of learning environments based on semantic web services (SWS) that are still in the early stages of development. This paper introduces a proprietary architectural model for distributed e-learning environments based on semantic web services (SWS), enabling the implementation of a successive learning process by developing innovative learning objects based on modern learning methods. A successful technical implementation of our approach in the environment of Kaunas University of Technology is further detailed and evaluated.
Keywords: learning object, semantic technologies, web applications, learning environments.

1 Introduction

A variety of tools and systems could be used for the implementation of learning activities through e-learning processes. When talking about e-learning technologies the most important and painful question we get is: what method should be used for the integration of interactive learning objects (LO) in the development of e-learning? The painful thing about this question is that a usual questioner has often been misled to believe that there is only a single tool that does everything that everybody needs to be done: to create, host, and access e-learning material. Successful e-learning strategies and scenarios may require integration of dozens of software products chosen from hundreds of candidates sprawling across multiple categories: development of learning objects, delivery of knowledge, content management, communication and collaboration, live learning and assessment, etc. They can also be categorized according to the possibilities of implementation of curriculum (realization of learning events: imitate, receive information, exercise, explore, experiment, create, self-reflect, debate); technological properties (e.g. synchronous, asynchronous, web based, PC application, mobile application, open source, free service); application domain (language learning, intercultural competences, ICT skills, time management skills, study habits skills, etc.). However, independent on the purpose or functionality, all tools and systems are often integrated in the virtual learning environment (VLE), which can reflect the discipline by providing a well-designed, visually stimulating interface that genuinely supports the needs of real world learning. A web-based education method suits this by providing more flexibility and intelligence. However, recent developments in the area of Semantic Web, while contributing to the solution to these problems, also raise new issues that must be solved [3].

The aim of the research in this paper is to present an architectural model of distributed e-learning environments based on semantic web services (SWS) with a goal to improve the effectiveness of a learning process by introducing innovative learning objects that combine variety of multimedia elements and other learning material as well as structural integrity of advanced learning methods. Extraction of semantic relations has always been a challenging problem in multimedia data. Various architectures of multimedia databases have been developed in the past but the need to refine them still remains in order to get the desired results of users' interest, to extract semantics from multimedia data in a way the user perceives them.

2 Related works

Interactive learning possibilities were improved with the introduction of internet technologies; however, it still fails to reach the full potential. With new, more interactive internet technologies there is even more to be captured and adopted, such as the public knowledge contained in blogs, wikis, social bookmarking services, social networks, etc. [8, 17]. The ontologies, the Semantic Web, and the Social Semantic Web offer a new perspective on intelligent educational systems by providing intelligent access to and management of Web information, and semantically richer modelling of applications and their users [2-3]. This allows supporting more accurate representations of learners, their learning goals, learning materials and contexts of use, as well as more efficient access and navigation through learning resources with a primary aim to advance intelligent educational systems to achieve improved e-learning efficiency, flexibility, and adaptation for both single users and communities of users.

The notion of the Social Semantic Web describes an emerging design approach for building Semantic Web applications that employs Social Software techniques. Social Semantic Web systems typically elicit domain knowledge through semi-formal ontologies, taxonomies or folksonomies.

Techniques related to educational content could be provided in different forms [1, 9, 18] and environments that have relations with semantic web services. As web-based education, it has become a very important branch of educational technology [2, 7, 19]. Classroom independence and platform independence of web-based education, availability of authoring tools for developing web-based courseware, cheap and efficient storage and distribution of course materials, hyperlinks to suggested readings, digital libraries, and other sources of references relevant for the course are but a few of a number of clear advantages of Web-based education. By analysing design of learning objects and essential characteristics of a range of proven learning activities, we can generate a set of requirements for the IS architecture. For example, a proven existing learning activity based on implementation of learning objects might enable students to work simultaneously across a network on a design tool, such as a graphics program, and share the results in separate windows. This learning activity therefore generates the computational requirement to allow the use of any shareable application this way.

Other researchers [6, 9, 10] have analysed a number of digital resources to be used and reused for learning (learning objects) and concluded that a number of those is constantly increasing. Therefore, description of learning objects with metadata is important as it allows enhancing search, retrieval and usage of learning objects and because it is very important in the integration process into any environment to efficiently organize a training process. Learning objects can be considered not only as resources providing affiliated materials, but also as methodological resources which include teachers' experiences, reflections, examples or instructions of usage of content objects and descriptions of learning methods [9, 18]. However, existing standards and specifications for learning objects metadata are not intended for including methodological

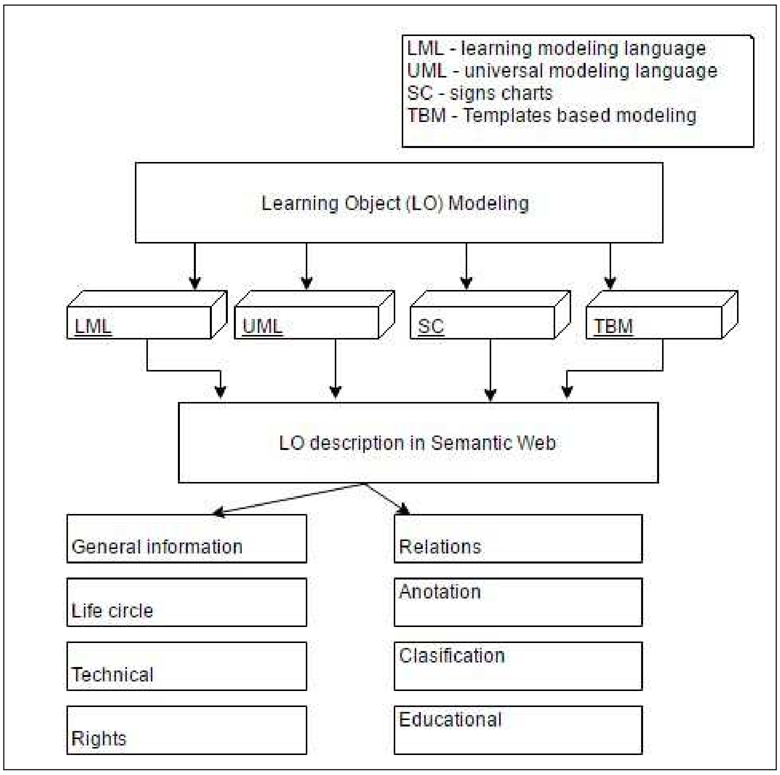

Figure 1: Principal schema of learning objects relations

resources and learning method descriptions together with content objects.

Modeling of learning objects and search of learning objects of the same content in the semantic web is a challenge to every researcher. The metadata and ontologies (see Fig. 1) let to find and to reuse learning objects in different situations as they make LO machine-understandable. According to Rehman and Kifor [21], ontologies are like repositories: they are helpful in exchange of knowledge, reusing existing knowledge, for reasoning and inferring on existing knowledge.

Dagiene et al. are discussing that digital learning resources by themselves are not as valuable as their target application in the learning process as well as a properly selected learning method. Therefore, metadata is indispensable and semantic web services should be intended part of the design of learning objects.

The systematically prepared corpus of metadata helps all the parties involved in learning process to cooperate, use and share learning resources [16], [13].

Interface of a learning object usually presents the same content and has the same look and feel for every user, regardless of a student's learning needs and individual characteristics. Some interfaces are "customizable"; the user can choose to modify some characteristics of the graphical user interface. However, this does not entirely satisfy the needs of educational content presentation to the users. Aspects of content personalization, proper interaction and efficient presentation are also important.

Some research on a design of learning objects has been already conducted [4]-[6] and some researchers [18] made the effort to combine learning objects and constructivism focus largely on how learning objects can be used in specific constructivist learning environments instead of building a universal generic structure.

The results of research presented by Gurbuz et al. [5] suggest that a new architectural model for learning objects development must be designed with a common login system that provides

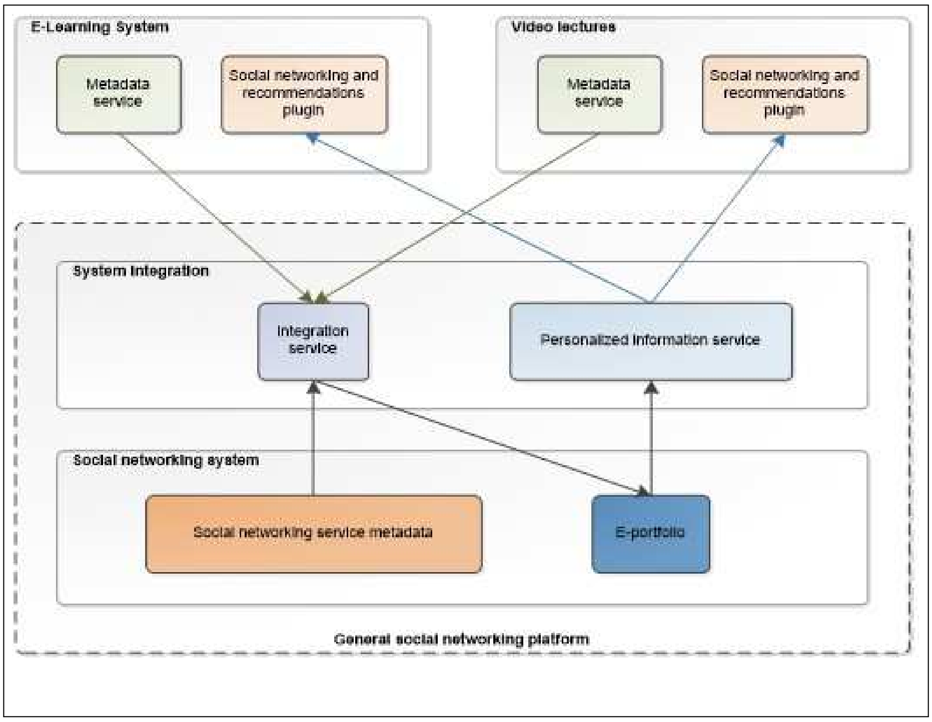

Figure 2: Architectural model of the platform

information about a person trying to connect (for example, name, address, email address, user code).

Aroyo at al. [10] and Gote et al. [7] have found a key to enable the interoperability and to capitalize on the semantic conceptualization and ontologies, common standardized communication syntax, and large-scale service-based integration of educational content and functionality provision, and usage based on a model of Semantic Web Services for Education.

The central role in achieving unified authoring support plays the process-awareness of authoring tools which should reflect the semantic evolution of e-learning systems.

Gurbuz et al. [5] present a system architecture model which is designed and based on service-oriented architecture technology (SOA). This architecture intended to provide an ability to create a flexible system focused on the provision of services with the ability to implement effective services and systems solutions for an integration of standard learning objects into information systems.

The platform (see architectural model of the platform in Fig. 2) can be structured in the following logical levels [10]-[12]:

- User level, consisting of user and system interfaces, implemented according to user specification and system requirements;
- The level of External systems; the adapter is provided for managing Web services. In addition, a system of components is required for external inclusion;
- The data level involves all data management, sanctioning, monitoring, archiving and storage components.

When connected to one of the web services by the use of other systems the second time logging is not necessary anymore as the system automatically checks the permission of online users and

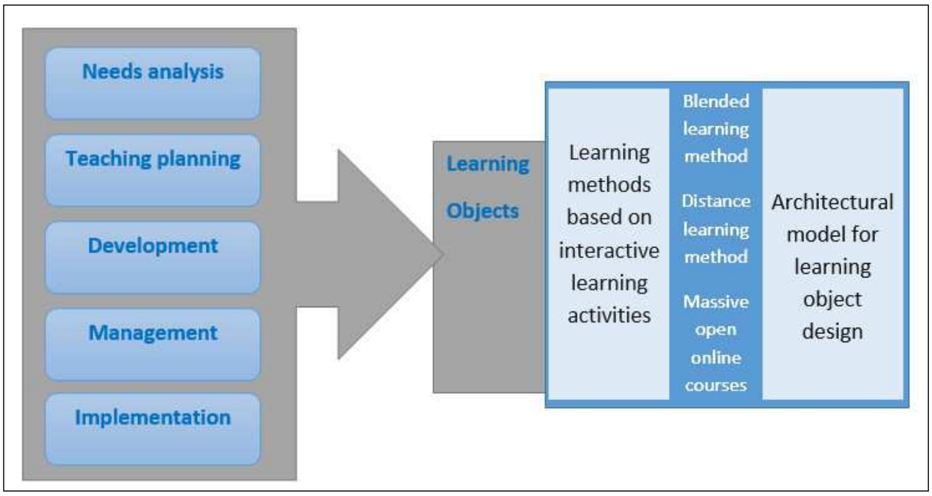

Figure 3: Integration of learning objects into interactive learning courses

authorizes them. The architectural model provides main functionality necessary for the design and implementation of learning objects.

A central role of achieving unified authoring support plays the process-awareness role of authoring tools which should reflect the semantic evolution of e-learning systems [14], [15], [20]. The researchers are working on the novel architecture of learning objects to solve the problem of unification of learning objects and to start working on standardization of LOs and to offer templates to users to design content based learning objects for e-learning systems related to semantic web services technologies.

The semantic relations with the learning objects are well constructed and to be provided from learning objects' interface.

3 A proprietary model of building LOs for semantic e-learning environments (SWS)

We propose a novel architecture for designing modern learning objects that can be easily applied to various domains.

A model is based on identified key learning objects phases that make an influence on the organization of study process as well as on finding technological solutions to design LOs and to develop technical implementation. We have carried out a comprehensive data analysis on the implementation of e-learning processes starting with the requirement specification to the delivery phase. In the evaluation, we have analysed the design of learning objects, methods of learning (i.e. blended learning method, distance learning method, etc.) and methods of providing massive open online courses.

The architectural model (see Fig. 4) was designed theoretically (based on the state of the art and best practice scenarios); its implementation started on a step-by-step basis. One of the requirements was to include metadata of each section that could be used to provide some useful information about the task goal, keywords, background, etc. Going up to the knowledge granularity level (see Fig. 3), multiple sections can form a component. Multiple components related to a learning topic can be grouped. When a learning object is generated by an instructor/author, the expert's experience can be embedded into the configuration of the course, such as selection of section contents, selection of components, sequence of components, display modes of components, etc. When it is generated by the learning environment, certain organizational

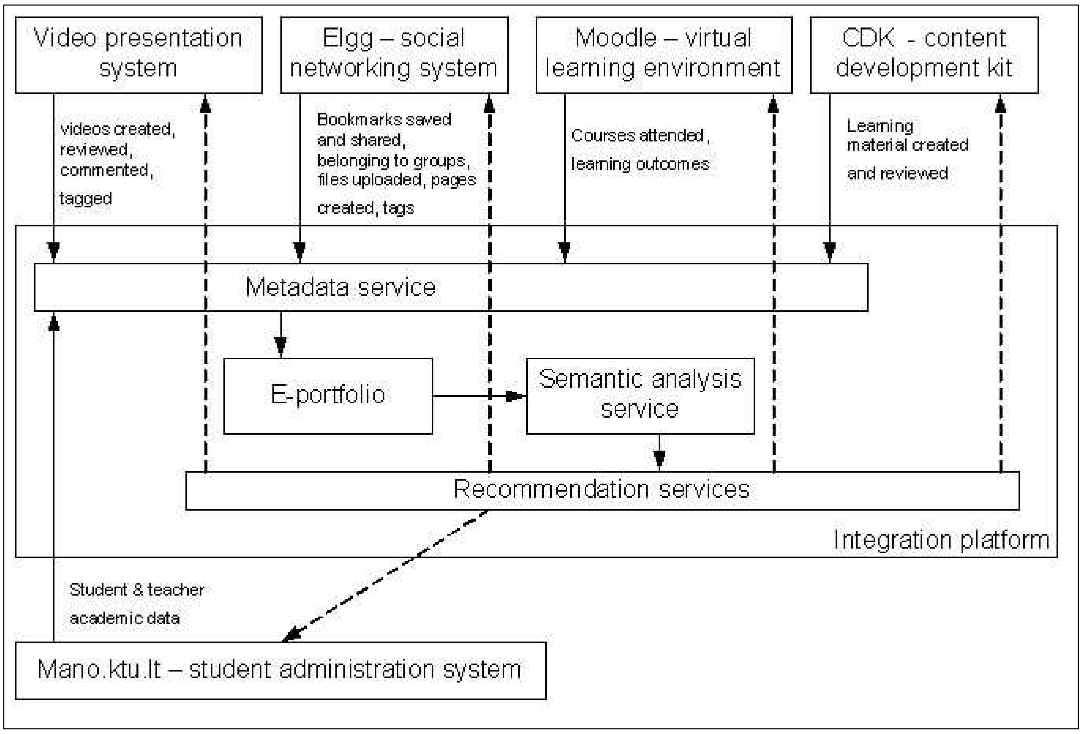

Figure 4: Architectural model for the design and delivery of learning objects

patterns can be applied to generate a course corresponding to the learner's profile and to the learning goal.

The architecture is based on SOA principles. The functions will be provided as services; the internal service processes are intended to optimize the use of the provision of direct procedure calls that can be realized directly in the server application procedures. Some kind of activities can be performed as services and will be directly integrated into learning objects.

Through the components of Web Services (WS), there is a possibility to take an advantage of the VLE and its functionality which provides a specific service such as data recording, getting a report, etc. Moreover, the service component of our system can be used to work in a workflow. The workflow can be used for both systems and services of VLE IS provided by external integrated systems.

IS and all its components are adapted using standard IT platforms, operating [13], [16] systems and existing computer network infrastructure. Information system can provide non-formal education and implementation of learning objects as well as self-tests carried out in the content management system that assures this essential functionality and the relations by semantic web services directly to content of learning objects, including preparation of learning objects, metadata description and semantic relations to other open resources; development of self-tests, integration into the software facilities; learning objects, learning programs and courses in preparation of and public access to its management; IS and user administration.

High resolution digital objects are stored in our university's VLE IS repository at open.ktu.lt. These objects must then be converted (transformed) into different formats and quality facilities for further implementation and content creation of different types (for different training programmes and courses).

IS and it's components are designed to work in the environment which was adapted to communicate with standard IT platforms, operating systems and the computer network.

Looking to the IS on student interface we can view learning objects in different ways. One way is to click "view default" to choose to view the course created by the author/instructor if such a version is available. Alternatively, students can choose and have the course generated automatically by the system according to some patterns like some external teaching methodology. There is a way to have a choice to view the learning objects sorted by the profile by which the learning materials will be generated session by session. Finally, students can choose to view all of the raw components related to the topic.

Our approach demonstrates the possibility of using the constructivism learning theory to guide the design of learning objects based upon the original prototype. The collaboration among authors of LO's is supported, while learners can also actively participate in the construction of learning objects. It provides a way to allow learners to grasp the whole picture of the course quickly. The ease of viewing contents of learning objects iteratively in different ways assists learners to learn efficiently in constructivist learning environments.

Through the Web Services (WS) components of the system, users and designer can take an advantage of the VLE and its functionality which provides specific services, such as initiating business processes to record data to get a report and so on. Besides, the service component of the system can be used to work in the workflow. Workflow can be used for both VLE IS systems and services provided by external integrated systems.

Some parts of the described system are under constant improvement. Changes in system functionality processes have to be implemented and adapted to the system. Our proposed process modelling makes it easier to adapt to the emerging new needs, for instance, to decide to adjust the sequence of necessary steps to abandon any of the steps to change the conditions of implementation steps.

The workflow can be easily incorporated during the steps carried out by the external system via services (service), as well as allow to easily changing the step executor. For example, a workflow step is carried out by an external system which presents the results of the VLE from that system.

IS functions will assure the insertion of educational content (including different format of learning objects), testing, and content development: development of digital material and metadata description; design of learning objects, design of courses and open access management; development of tests and assignments and relation to the targeted program; virtual learning environment and users administration.

Key property of the Semantic Web architecture (common-shared-meaning, machine-processable metadata), enabled by a set of suitable agents, seems to be powerful enough to satisfy the e-learning requirements: fast, just-in time and relevant learning. Learning material is semantically annotated and it may be easily combined in a new learning course in case of a new learning demand [23]. The process is based on semantic querying and navigation through learning materials enabled by the ontological background. In fact, the Semantic Web could be treated as a very suitable platform for implementation of e-learning objects since it provides all means for (e-learning) ontology development, ontology-based annotation of learning materials, their composition in learning courses and (pro)active delivery of the learning materials through e-learning portals.

In our system, learning objects are distributed on the web but they are also linked to agreed network of ontologies. This enables construction of user-specific courses by allowing semantic querying for various topics of interest. Software agents of the Semantic Web can be used to enable co-ordination between other system agents and proactive delivery of learning materials in the context of actual problems.

The Semantic Web can be as decentralised as possible. This enables an effective co-operative content management. Content is determined by an individual user's needs and aims to satisfy the needs of every user. The users by using personalised agent searches for learning material will be customised for her/his needs. The ontology is the link between user needs and characteristics of the learning material.

The Semantic Web enables the use of knowledge, provided in various forms, regarding semantic annotation of content.

Distributed nature of the Semantic Web enables continuous improvement of learning materials. It enables the use of distributed knowledge provided in various forms, enabled by semantic annotation of content. Distributed nature of the Semantic Web enables continuous improvement of LO.

4 Practical realization of the designed architectural model for learning objects development

The developed architectural model for the design of learning objects includes content development tools and social network integration and video lecturing system. The content acquisition and control measures were implemented by using the open-source virtual learning environment Moodle, an open source social networking system ELGG and open-source Drupal CMS integrated with a system for video lecture recording as well as the tool CKD dedicated to the development of learning objects. The system allows users to create / edit / delete content, search, use e-learning content and share with other users for evaluation. Facility installed and configured user roles and rights connected allow to form a single login system within active web services, in order to produce the information and allow for service centres to carry out the instructions sent by the inclusive media.

Semantic tools have been implemented to assist the workflow of course creation delivery, to revise a recommendation process of a relevant content and people in the context of the course and the institution, to assist students by recommending resources that match the topics of their assignments and personnel that may be able to support their activities, to help in group formation for collaborative work based on students' background, personal preferences and successful prior collaboration, to add support for critical thinking and argumentation by visualizing arguments and linking relevant discussions.

Implementation of semantic technologies allowed enabling integration, searching and matching of nodes of information. Large university repositories, like triple stores, where information can be efficiently stored, searched and managed, were also improved by a more efficient semantic model.

According to the architectural model presented in the section 2, changes were made to IS distance learning management system "mano.ktu.lt".

The platform was created with the idea to aggregate the information distributed by different institutional departments including personal user's needs (portfolio). This system data of user activity is gathered by metadata service from different e-learning systems. Metadata is then structured and saved as a user e-portfolio. Semantic analysis service is activated on user e-learning event, for example, the user is logging to any of the platform's systems. Semantic analysis service gets e-portfolio data and performs semantic analysis using several methods: user-based Collaborative Filtering, cosine similarity, person correlation, jaccard - tanimoto index, Sorensen coefficient.

Recommendations for learning materials and other users (for promotion of collaboration) are presented to the active user after an analysis is performed in the plugin of the environment where the user is performing his learning activities. For example, if a user is in a video presentation system, s/he gets similar videos based on the analysis of all data on all systems together (semantic proximity between users in elgg, moodle, cdk, mano.ktu.lt environments is analysed) – if two

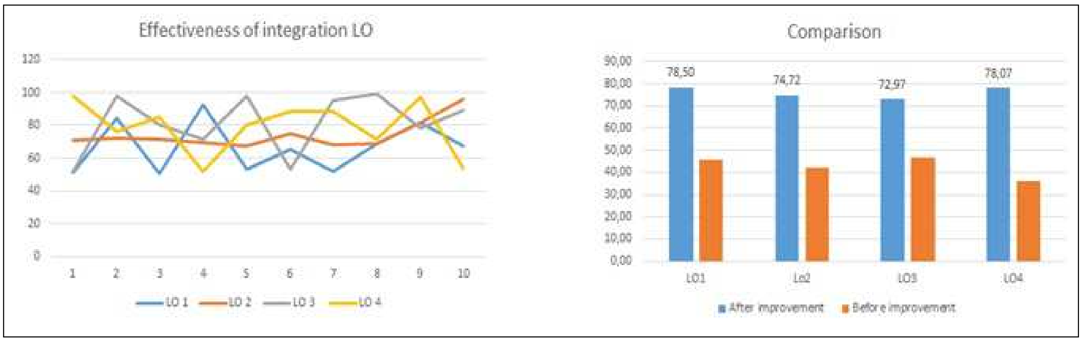

Figure 5: Effectiveness of LO integration

and more users collaborate in the same elgg group, they might want to check the same videos on a video presentation system.

5 Initial experimental evaluation

As there is no way to effectively introduce objective measures for other than performance tasks, a specified survey was issued to conceive the effectiveness of current milestone version. The users were requested to answer the questionnaire and express their opinion on the design and delivery of learning objects as well as about practical implementation of LOs into the institutional system: if it is friendly, easy to use or not.

The research was implemented on national institutional level where 94 authors of academic courses were requested to answer the questionnaire. 54 % of respondents were aged between 45-60 and 46 % were aged between 30-45. The respondents were requested to answer the main question which technological solutions dedicated to design learning objects were friendlier to use? From an age perspective, we can claim that age was not a very important factor and the respondents were interested in learning this novel architectural model and were coping easily with a standard template to design interactive learning object that does not require special competences to provide an interactive learning content to students.

We have also asked to compare the creation of standard learning objects vs non-standard learning objects used in educational process. The result showed that the users were friendlier with the standard objects (see a comparison of usability of learning objects based on the architectural model and not in Table 1) where the number of respondents provided data on the LO usability in the architectural platform.

The experimental research on the effectiveness of LO integration (see Fig.5) was carried out by means analysing data on the platform developed on the architectural model (see Fig. 4) and using of high resolution learning objects to be provided for the study process. In other cases the supplied video objects have proven as a more effective way to work with students who were in different locations, and to leave video records for self-learning as well. This is true even for the development and delivery of massive open online courses in our university.

According to the respondents, successful integration of architectural model into practice opened an easy way to teachers and lecturers to make video records of lectures.

After tuning a model on the remarks of our experimental participants, a component of video conferencing system was modified into a more user-friendly experience (VIPS, http://vips.liedm.lt) was developed. IS environment became very friendly to use due to a novel combination of modern technologies and established methods of pedagogy.

Conclusions

New approaches of the learning objects modelling plays the central role in achieving unified authoring support in the process-awareness of authoring tools which should reflect the semantic evolution of e-learning systems. However, the researchers are working on the architecture on LO design to solve the problem of the unification of learning objects and to start standardization of LOs and to suggest the templates for users designing content based standard learning objects for e-learning systems based on semantic web services technologies.

For conclusions the authors identify that the developed model offers perfect technology and environment for individualized learning based on interactive learning objects not only for teachers but for learners as well, as they can be uniquely identified, content can be specifically personalized, and the learning progress can be monitored, supported and assessed.

The ontologies, the Semantic Web, and the Social Semantic Web offer a new perspective on intelligent educational systems by providing intelligent access to and management of Web information, and semantically richer modelling of applications and their users.

The Semantic Web enables the use of distributed knowledge provided in various forms, provided by semantically annotated content. Distributed nature of the Semantic Web enables continuous improvement of learning objects.

The research data shows that architecture for the design of learning objects can be applied to various domains and that authors can easily work with in order to design and integrate of learning objects. At the same time, the technological solution for architectural model based on semantic web services cannot be influenced by the age of users as this is not very important and the respondents were interested in architectural model and standard template to design interactive learning object having very easy technologies that do not require special competences to provide to students interactive learning content.

Bibliography

[1] Ermalai, I.; Dragulescu, B.; Ternauciuc, A.; Vasiu, R. (2013); Building a Module for Inserting Microformats into Moodle, *Advances in Electrical and Computer Engineering*, 13(3): 23-26.

[2] Kruk, S.; Gzella, A.; Dobrzanski, J.; McDaniel, B.; Woroniecki, T. (2007); E-Learning on the Social Semantic Information Sources, *Lecture Notes in Computer Science*, 4753: 172-186.

[3] Ermalai, I.; Mocofan, M.; Onita, M.;Vasiu, R. (2009); Adding Semantics to Online Learning Environments, *Proceedings of 5th International Symposium on Applied Computational Intelligence and Informatics – SACI2009*, 569-573.

[4] Targamadze,A.; Balbieris, G.; Kubiliunas, R. (2005); The new generation of virtual learning environments in Lithuania, *Information Technology and Control*, 34(3): 276-284.

[5] Gurbuz, T.; Gudoniene, D.; Rutkauskiene, D. (2013); System architecture model based on service-oriented architecture technology, *Proceedings of 19th international conference Information and Software Technologies*, 102-113.

[6] Kurilovas, E.; Dagiene, V. (2009); Multiple Criteria Comparative Evaluation of E-Learning Systems and Components, *Informatica*, 20(4): 499-518.

[7] Grtze, P.; Engelund, C.; Mortensen, R.L.; Paszkowski, S. (2009); Cross-National Interoperability and Enterprise Architecture, *Informatica*, 20(3): 369-396.

[8] Abdul Hamid, O.; Abdul Qadir, M.; Iftikhar, N.; Ur Rehman, M.; Uddin Ahmed, M.; Ihsan, I. (2007); Generic Multimedia Database Architecture Based upon Semantic Libraries, *Informatica*, 18(4): 483-510.

[9] Dagiene, V.; Jevsikova, T.; Kubilinskiene, S. (2013); An Integration of Methodological Resources into Learning Object Metadata Repository, *Informatica*, 24(1): 13-34.

[10] Aroyo, L.; Dicheva, D. (2013); The New Challenges for E-learning, *The Educational Semantic Web Educational Technology & Society*, 7 (4): 59-69.

[11] Rutkauskiene, D.; Gudoniene, D.; Cibulskis, G.; Suk, O. (2013); ICT architecture for online learning approach, *Proceedings of Information and software technologies - ICIST 2012*, 373-387.

[12] Rutkauskiene, D.; Mark, R.; Kubiliunas, R.; Gudoniene, D. (2013); Functional architecture of a service-oriented integrated learning environment, *Proceedings ECEL 2013 - 12th European Conference on e-learning*, 431-439.

[13] Kuzucuoglu, A. E.; Gokhan, E. (2011); Development of A Web-Based Control And Robotic Applications Laboratory For Control Engineering Education,*Information Technology and Control*, 40(4): 352-358.

[14] Bajec, M. (2008); A Framework and Tool-Support for Reengineering Software Development Methods, *Informatica*, 19(3): 321-344.

[15] Bersin, J. (2008); Social Networking and Corporate Learning, *Certification Magazine*, 10: 14-14.

[16] Fertalj, K.; Hoic-Bozic, N.; Jerković, H. (2010); The Integration of Learning Object Repositories and Learning Management Systems, *Computer Science and Information Systems*, 7: 387-407.

[17] Grodecka, K.; Wild, F.; Kieslinger, B. (2011); *How to Use Social Software in Higher Education*, Poland.

[18] Targamadze, A.; Petrauskiene, R. (2010); Impact of Information Technologies on Modern Learning, *Information Technology and Control*, 39(3): 169-175.

[19] Vitiutinas, R.; Silingas, D.; Telksnys, L. (2011); Model-driven plug-in development for UML based modelling systems, *Information technology and control*, 40(3): 191-201.

[20] Alsultanny, Y. (2010); e-Learning System Overview based on Semantic Web, *The Electronic Journal of e-Learning*, 4 (2): 111-118.

[21] Rehman, Z.; Kifor, S. (2014); A Conceptual Architecture of Ontology Based KM System for Failure Mode and Effects Analysis, *International Journal of Computers Communications & Control*, 9 (4): 463-470.