Meta Model of e-Learning Materials Development

Signe Balina[1], Irina Arhipova[2], Inga Meirane[3] and Edgars Salna[3]
[1] *University of Latvia, Faculty of Economics and management, Aspazijas Blvd. 5, Riga, Latvia*
[2]*IT Kompetences centrs, Lacplesa str. 41, Riga, Latvia*
[3]*Datorzinibu centrs JSC, Lacplesa str. 41, Riga, Latvia,*

Keywords: e-Learning Objects, e-Learning Materials, e-Learning Standards, Metadata Models, e-Learning Management Systems.

Abstract: The multitude of software tools is available for the creation of learning resources. However the majority of these tools provided by different software producers do not have a unified mechanism by means of which it would be possible to search and reuse the existing learning resources or their elements. To solve this problem the structures of descriptive data can be used. The aim of this paper is to describe a meta-model of e-learning objects and e-learning formats that could be used in the creation of e-learning materials compatible with various e-learning standards. The meta-data models that are used in widely-known learning resources' repositories and their structure's metadata standards providing cross-system compatibility have been evaluated. The key metadata standards of learning objects were identified and their comparative analysis was performed. The e-learning material logical model was created and the essential demands for e-learning object's data repository were defined. The technologies and their provided electronic learning objects' classification systems were investigated for the future development of e-learning materials. The scheme of e-LM development process was obtained, which provides the transformation of different modules.

1 INTRODUCTION

Nowadays the necessity for progressive means for teaching has significantly increased due to the usage of modern technologies in educational process. E-learning materials have gradually become a part of those modern tools by means of which new knowledge, skills and proficiencies are acquired both in general education and in the life-long learning. The problem occurs due to the rapid development of technologies – the emergence of various new formats and devices makes a long-term and repetitive usage of e-learning materials difficult.

The e-learning content otherwise constant is represented in various formats for the usage on computers with different operational systems or for the usage in mobile devices. These various types of representation of e-learning resources are created by means of different technological tools, which consequently lead to a multitude of technical formats and standards. These tools range from presentation programs to complicated programming environments provided by different software producers thus lacking a unified mechanism of searching and reusing of existing learning resources or their elements.

To solve this problem the structures of descriptive data can be used. These structures can be described as "data about data" and if such data are organised accordingly to the pre-defined structure they can be used as metadata.

Generally metadata is information about a digital object by means of which the object can be retrieved from the database. In this paper the concept of "metadata" is attributed to the learning objects as follows: elementary electronic learning objects (ee-LO), electronic learning objects (e-LO), and electronic learning materials (e-LM). The metadata of these learning objects can be stored either within e-LM or separately for the development of new e-LM. Therefore it is necessary to investigate the technologies and their classification systems of e-LO (Anido et al., 2002). The idea of e-LO classification scheme is based on the presumption that it would enable to develop the system which allows create multimedia rich and interactive e-LM, reuse it, update, improve, translate, and address it to various target audiences.

Balina S., Arhipova I., Meirane I. and Salna E..
Meta Model of e-Learning Materials Development.
DOI: 10.5220/0004971401500155
In *Proceedings of the 16th International Conference on Enterprise Information Systems* (ICEIS-2014), pages 150-155
ISBN: 978-989-758-029-1

The aim of this paper is to describe a meta-model for e-LO and e-LM formats that could be used in the creation of e-LM, which is compatible with various e-learning standards (SCORM, IMS etc.). To reach this aim the following tasks were performed:

- to analyse the current situation of e-learning materials development;
- to evaluate meta-data models used in repositories of widely-known learning resources and their metadata standards used for providing cross-system compatibility;
- to identify main e-LO metadata standards and to perform their comparative analysis;
- to create e-LM logical model and to define e-LO data repository prerequisites;
- to describe e-LM development process.

2 THE CURRENT SITUATION OF E-LM DEVELOPMENT

E-LM encompasses different electronic learning objects meant for content representation and motivation of learners. These electronic learning objects consist of certain content which from the pedagogical point of view is an inseparable unit of information, and it has the predefined type of object's representation in the particular e-LM. The content of e-LM comprises pictures, text, audio, and video, various types of multimedia. Meanwhile multimedia not only enriches the content of e-learning material but also attracts more users, improves learning experience and learners' knowledge (Dong & Li, 2005), (Shang et al., 2001), therefore it is important to pay attention to the incorporation of multimedia in e-learning especially regarding adaptive content for learners. This effective usage of multimedia is extensively discussed in the research by Benson, V., Frumkin, L. and Murphy, A. (Benson et al., 2005). Benson, V. has researched also the aspects of flexibility of electronic educational materials by structuring multimedia components. He also provided the description of the system how to integrate multimedia components into e-learning environment (Benson et al., 2005).

Lin, M.L.M. et al. made a research for developing such design and principles as to implement multimedia in learning system, which can generate browsing structure, for example, the content and hyperlinks of hierarchic tables. Taking this system as the sample the research was carried out for analysing the relation between the browsing structures and effectiveness of students' learning. The result was positive and it proved that browsing structures allow students get better results (Lin et al. 2006).

Learning content personalisation and adaptation has also been in the focus of many researchers. Mei, Q.M.Q. and Shen, J.S.J. have developed a personalized e-learning system which is based on the flow of knowledge (Mei and Shen, 2002). Whereas Xu, D., Wang, H. and Wang, M. described the conceptual model for personalized virtual learning environment which could be perceived as a responsively constructed learning model (Xu et al., 2005).

These researches were taken into account in the creation of e-LO classification schemes, i.e., in the creation of models of e-LO content, their hierarchical structure and collaboration mechanisms between models of content and their representations performed in this paper.

3 META-DATA MODELS AND STANDARDS

The initial aim of the metadata is to make the search for e-learning materials, their usage and re-usage simpler and more effective by providing pre-defined structure of elements which describes learning resource and its usage parameters, as well as representation methods (Ieee-Lom, 2002).

The standardization of learning object's metadata has been taking place worldwide in various organizations for almost several decades. During this period of time two metadata models of learning objects have become the standards – IEEE LOM base scheme and *Dublin Core* (DCMI, 2013) set of basic elements.

Summarizing the information about the repositories of learning objects created in USA and Australia such as AMSER, Connexions, EDNA, and GEM, it became clear that primary the *Dublin core* metadata scheme was used (Najjar J. 2008). Meanwhile the IEEE LOM metadata scheme primary was used in the learning objects repositories created in Europe, USA, and Canada, as well as within the framework of some international projects such as ARIADNE, CAREO, CLOE, Exploratories, Harvey Projects, iLumina, Jorum, MERLOT, NSDL, Orange Grove, SMETE, and VCILT.

There are several well-known repositories (DLESE, CITADEL, EducaNext, TLF, and FAO LR), various personalized libraries and vocabularies, which have chosen a hybrid model for their

metadata model using both IEEE LOM and *Dublin Core* metadata.

Nine out of 21 repositories, which were analysed, use partly or fully adapted metadata elements provided by *Dublin Core* metadata standard. Meanwhile the IEEE LOM metadata scheme was used for the basis or in the combination with *Dublin Core* for all 16 repositories with the adjustments made accordingly to the system (selectively chosen metadata elements, alternative vocabularies etc.).

Hybrid type meta-models are frequently used comprising both *Dublin Core* and LOM metadata elements, supplemented with the unique elements for specific aims.

The same principle can be found in the value vocabularies, which can be shared differently depending on the specific needs of the solution.

4 THE KEY META-DATA STANDARDS

It was evident that the primary focus is on two meta-data standards: LOM and DCMI. It is necessary to identify similar data elements in these standards which could be compatible, as well as to analyse the usage of individual elements in various systems from the perspective of frequency of their usage and frequency of searching by users.

Similarly, it was considered worthwhile to investigate the legacy of data elements as a result of decomposition when the data elements of lower aggregation level (derived as a result of a decomposition of a learning object of a higher aggregation level) inherit a part of metadata.

The global practice shows that despite the fact that these standards have been in existence for more than ten years and remarkable amount of work has been done for the development of these standards, there are few repositories where they are used in their direct form.

For the majority of the most popular repositories of electronic learning objects these standards are taken over by making adjustments in the metadata scheme. These adjustments are of the most various kind, for example:

- the elements of both standards are used in a symbiosis. The most commonly spread symbiosis is the supplementation of the *Dublin Core* set of basic elements, for example, the supplementation with the specifically needed metadata elements of software taking them over from IEEE LOM. This method is possible due to the flexibility of *Dublin Core* set of basic elements;
- although a metadata standard is chosen its elements are not fully used – the set of elements are narrowed to the specific elements necessary only for the particular software, and elements are classified by their significance;
- a metadata standard is chosen using only a part of its elements and adding new elements thus supplementing the chosen standard with the software specific data types or vocabularies of classifiers;
- various combinations of above mentioned scenarios are used.

5 E-LM LOGICAL MODEL AND E-LO DATA REPOSITORY

By means of the acquired knowledge about metadata, their aggregation levels (Friesen et al. 2002), as well as about structure models, it was possible to define e-LO original model which provides concise and structured overview of e-LO inner structure and its logic.

5.1 e-LO Original Model

e-LO original model identifies the possible structures and aggregation levels of e-LO, the interrelations of their characteristics, as well as the classification of e-LO metadata respective to their type and aggregation level. e-LO is generally characterised by its structure, type of representation and meta-information.

The acknowledged worldwide practice shows that the development of generally accepted and universal meta-model practically is not possible due to the general standards, which frequently cannot meet the demands of software users. Meanwhile the detailed standards, i.e., such standards, which could be applied for the overview of all possible scenarios, can be too difficult from the perspective of software users.

If there is only a need to describe small amount of elementary learning objects, the metadata scheme consisting of 60 elements is too broad and unnecessary for users (Ieee-Lom, 2002). The effective description of such an elementary learning object requires no more than 5-7 manually filled metadata elements.

There is not one definite standard for the development of data repositories which could be applied to all types of data repositories of electronic

learning objects, health data objects or objects of other branches. Each data repository has its specific sphere of action. In order to provide the repository's operation in its full value, several tasks should be solved. First of all, for the development of qualitative and correct operation of the repository it is necessary to investigate and thoroughly analyse the repository's data, its types, formats, structures, and interrelation. Secondly, the basic demands for the repository's data should be identified.

There are various technologies and methods for the development of databases. Each of these technologies has its definite scope and available functionality. The majority of database development technologies provide general functionalities by means of which it is possible to solve the specific tasks successfully. Therefore it is possible to choose the most appropriate solution developed by the standards of the industry and by a reliable and competent developer.

5.2 Architecture of e-LM Logical Model

For the storage of each e-LM the data repository should provide the storage of various types of objects and their characterising features which could change accordingly to the object's aggregation level and information indicated in the specific content of the particular object and at the same time also contain references to other objects.

E-LM, e-LO and ee-LO have their own information, which is not always available for the objects derived or created from their source objects, i.e., they have their own metadata, which should be made available for all object's descendants. e-LO and ee-LO also could be different types of objects each of which can be saved as a file with different size and content. In order to provide the system's performance the storage of data objects should be developed differently as it is for the storage of textual information.

For the storage of each of e-LO the data repository should provide the storage of all elements of e-LM logical model's content providing various versions and languages. E-LM can be made of e-LO or ee-LO, which are arranged in various structures.

These structures could be various types of graphs (for example, hierarchical, tree-type, or cyclic graphs) where the specific e-LO is its peak point and could contain references to other e-LO.

Figure 1 depicts the architecture of e-LM logical

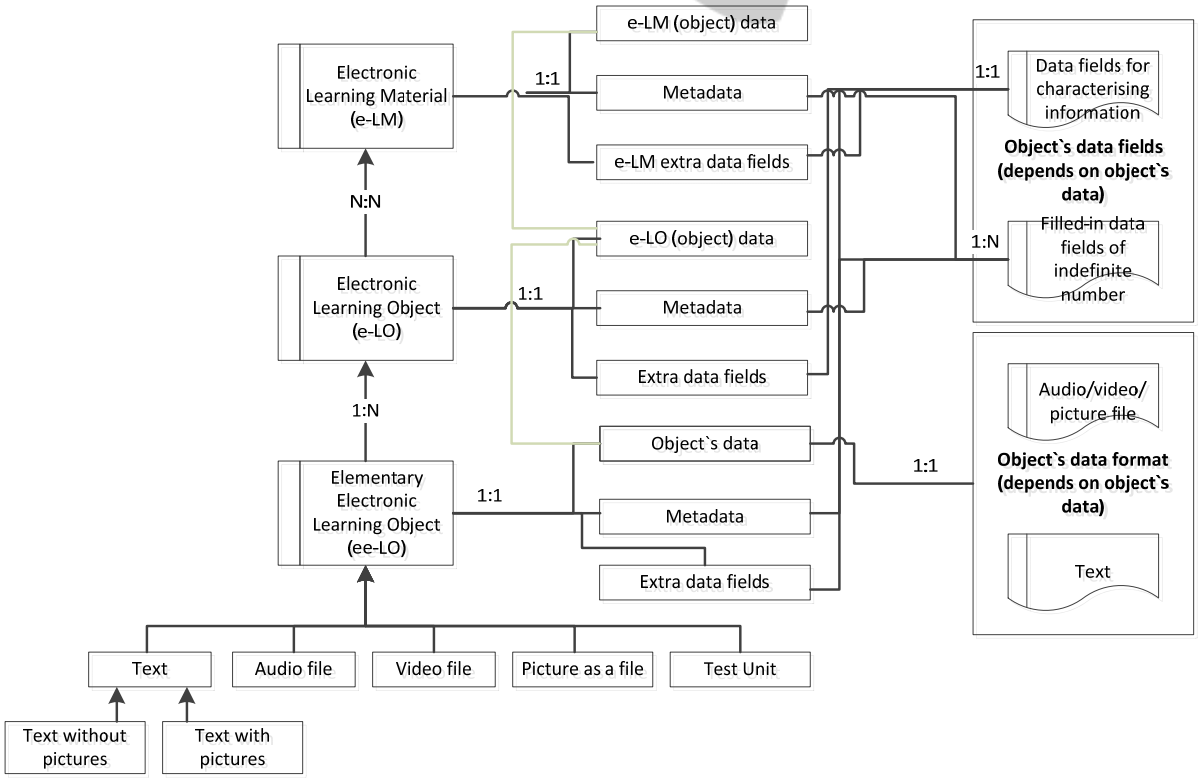

Figure 1: Architecture of e-LM logical model.

model with the representation of links between e-LM elements, their interrelations and possible technical solutions.

The data repositories' compliance to various types of e-LO storage, processing and output was defined by studying the available data repository solutions. Likewise the most appropriate e-LO storage technical solutions were defined providing the output of respective data repository's content. The suggestions and description of the potential e-LO data repository's development in off-line mode were additionally developed.

It is concluded that e-LO data repository's usage in its full value will be available solely in on-line mode but the opportunity to overview data can be developed also in off-line mode.

The conclusion is drawn that DBMS Microsoft SQL is suitable for the development of e-LO data repository since this type of database provides support not only for relational databases but also for the storage of non-structured data. This is an important factor for the processing of objects and files.

Microsoft SQL also provides various kind of support for the storage of files and binary information which is an alternative solution for „key-value" and makes an important factor for the storage of EO. Non-structured data storage opportunities are important for the processing of metadata provided by Microsoft SQL with XML data type realization.

6 THE PROCESS OF E-LM DEVELOPMENT

The content of e-LM is reusable if the development of e-LM is carried out accordingly to the definite process scheme. There are altogether three formally described and strictly defined e-LM development processes that refer to the specific quality demands and functionalities of the development of e-LM – the extraction of e-LM final results is carried out in accordance with e-LM development, e-LM translation, and EO creation processes.

By applying transformations to the appropriate models of process schemes, the e-LO classification scheme and e-LO original model were obtained.

Previously mentioned models can be improved as well as future models obtained as a result of successively taken actions. By defining the transitions of models and by making the actions formal it is possible to automate the model transformation from one model into another thus obtaining automatic model transformation and reducing the amount of manual actions. The reduced amount of manual actions increases the effectiveness of the developed solution or applied process.

The developed e-LM logical model (Figure 1) supplemented with the conditional module is transformed into HTML 5, which can be used in the generation of e-LM source code for specific technological solutions such as mobile applications, printable documents, and e-LM as web pages.

E-LM visualization model and the description of its operation can be performed in various steps that should be carried out as model transformations.

During the investigation of the process of e-LM development, such scheme of e-LM development process was obtained that allows the changes of different models by means of transformations. The models are defined in the level of their processes and technical realisation thus giving an opportunity to gain the models that are dependent or independent of specific type of technical realization.

7 CONCLUSIONS

The idea of e-LO classification scheme is based on the presumption that such a scheme would enable to develop the system which allows accumulate multimedia rich and interactive e-LM, reuse it, update, improve, translate, and address it to various target audiences. That is the approach to the problem and its possible solution, which cannot be found in the already existing tools. Thus the creation of e-LO classification scheme is a topical issue for the investigation and the development of appropriate software.

By assessing a range of the world's most popular learning objects' repositories and browsing services which are used in learning objects' metadata structures, it is concluded that two of the most popular learning objects' metadata standards are *Dublin Core* metadata initiative and IEEE Learning object metadata (LOMv1.0), which are excessively, individually, jointly or in a broadened form used in practically all of 21 investigated solutions of LO repositories. Despite the fact that these standards have been in existence for more than ten years and remarkable amount of work has been done for the development of these standards, there are few repositories where they are used in their direct form. For the majority of the most popular repositories of electronic learning objects these standards are taken over making adjustments in the metadata scheme.

The acknowledged world-wide practice shows that the development of generally accepted and universal meta-model practically is not possible due to the general standards, which frequently cannot meet the demands of software users. Meanwhile the detailed standards, i.e., such standards which could be applied to the overview of all possible scenarios can be too unwieldy from the perspective of software users.

The e-LO data repository's usage in its full value will be available solely in on-line mode but the opportunity to overview data can be developed also in off-line mode.

The conclusion is drawn that DBMS Microsoft SQL is suitable for the development of e-LO data repository since this database provides support not only for relational databases but also for the storage of non-structured data which is an important factor for the processing of objects and files.

During the research the e-LM development process scheme is obtained, which allows to change different models by means of transformations. The models are defined in the level of their processes and technical realisation thus giving an opportunity to gain new models that are dependent or independent of specific type of technical realization.

ACKNOWLEDGEMENTS

This research is part of a project „Competence Centre of Information and Communication Technologies" run by IT kompetences centrs, Ltd., contract No. L-KC-11-0003, co-financed by European Regional Development Fund.

REFERENCES

Anido, L. E. et al., 2002. Educational metadata and brokerage for learning resources. *COMPUTERS EDUCATION*, 38, pp.351–374.

Benson, V., Frumkin, L. & Murphy, A., 2005. Designing multimedia for differences: e-lecturer, e-tutor, and e-student perspectives. *Information Technology and …*, 2, pp.1–6. Available at: http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=1488947 [Accessed October 2, 2013].

DCMI, 2013. *Dublin Core Metadata Initiative*, Available at: http://dublincore.org/documents/dces/

Dong, A. D. A. & Li, H.L.H., 2005. Multimedia access platform for virtual learning environment. *2005 IEEE International Conference on Electro Information Technology*, pp.1–6.

Friesen, N., Roberts, A. & Fisher, S., 2002. CanCore: Metadata for Learning Objects. *Canadian Journal of Learning and Technology*, 28, pp.1–7.

IEEE-LOM, 2002. *Standard for Learning Object Metadata*, Available at: http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=1032843.

Lin, M.L.M. et al., 2006. Learning by Browsing: A Web-Based Multimedia Browsing System for Learning. *Proceedings of the 39th Annual Hawaii International Conference on System Sciences HICSS06*, 1.

Mei, Q.M.Q. & Shen, J.S.J., 2002. A knowledge flow driven e-learning architecture design: what is its stratification and how is it personalized. *International Conference on Computers in Education 2002 Proceedings*, pp.1307–1308 vol.2.

Najjar J. 2008. Empirical Evaluation of the Actual Use of Learning Objects and Metadata in Learning Object Repositorie. *Computer Science Department*, K.U.Leuven B-3001 Leuven, Belgium.

Shang, Y., Shi, H. & Chen, S.-S., 2001. An intelligent distributed environment for active learning. *Proceedings of the tenth international conference on World Wide Web WWW 01*, 1, pp.308–315.

Xu, D., Wang, H. & Wang, M., 2005. A conceptual model of personalized virtual learning environments. *Expert Systems with Applications*, 29, pp.525–534.