VILNIUS UNIVERSITY

Svetlana Kubilinskienė

EXTENDED METADATA MODEL FOR DIGITAL LEARNING RECOURCES

Summary of Doctoral Dissertation
Technological Science, Informatics Engineering (07T)

Vilnius, 2012

Doctoral dissertation was prepared at Institute of Mathematics and Informatics of Vilnius University in 2007-2011.

Scientific Supervisors

Prof. Dr. Valentina Dagienė (Institute of Mathematics and Informatics, Technological Sciences, Informatics Engineering – 07T).

The dissertation will be defended at the Council of Scientific Field of Informatics Engineering at the Institute of Mathematics and Informatics of Vilnius University:

Chairman

Prof. Dr. Habil. Gintautas Dzemyda (Vilnius University, Technological Sciences, Informatics Engineering – 07T).

Members:

Prof. Dr. Eduardas Bareiša (Kaunas University of Technology, Technological Sciences, Informatics Engineering – 07T),

Prof. Dr. Habil. Marija Barkauskaitė (Lithuanian University of Educational Sciences, Social Sciences, Educology – 07S),

Prof. Dr. Albertas Čaplinskas (Vilnius University, Technological Sciences, Informatics Engineering – 07T),

Prof. Dr. Habil. Genadijus Kulvietis (Vilnius Gediminas Technical University, Technological Sciences, Informatics Engineering – 07T).

Opponents:

Dr. Olga Kurasova (Vilnius University, Technological Sciences, Informatics Engineering – 07T),

Prof. Dr. Habil. Aleksandras Targamadzė (Kaunas University of Technology, Technological Sciences, Informatics Engineering – 07T).

The dissertation will be defended at the public meeting of the Council of Informatics Engineering Science in the auditorium number 203 at the Institute of Mathematics and Informatics of Vilnius University, at 1 p. m. on 7 March 2012.

Address: Akademijos st. 4, LT-08663 Vilnius, Lithuania.

The summary of the doctoral dissertation was distributed on 5th of February 2012.
A copy of the doctoral dissertation is available for review at the Library of the Vilnius University.

VILNIAUS UNIVERSITETAS

Svetlana Kubilinskienė

IŠPLĖSTAS SKAITMENINIŲ MOKYMOSI IŠTEKLIŲ METADUOMENŲ MODELIS

Daktaro disertacijos santrauka
Technologijos mokslai, informatikos inžinerija (07T)

Vilnius, 2012

Disertacija rengta 2007–2011 metais Vilniaus universiteto Matematikos ir informatikos institute.

Mokslinė vadovė

Prof. dr. Valentina Dagienė (Vilniaus universiteto Matematikos ir informatikos institutas, Technologijos mokslai, informatikos inžinerija – 07T).

Disertacija ginama Vilniaus universiteto Matematikos ir informatikos instituto Informatikos inžinerijos mokslo krypties taryboje:

Pirmininkas

prof. habil. dr. Gintautas Dzemyda (Vilniaus universitetas, technologijos mokslai, informatikos inžinerija – 07T).

Nariai:

prof. dr. Eduardas Bareiša (Kauno technologijos universitetas, technologijos mokslai, informatikos inžinerija – 07T),

prof. habil. dr. Marija Barkauskaitė (Lietuvos edukologijos universitetas, socialiniai mokslai, edukologija – 07S),

prof. dr. Albertas Čaplinskas (Vilniaus universitetas, technologijos mokslai, informatikos inžinerija – 07T),

prof. habil. dr. Genadijus Kulvietis (Vilniaus Gedimino technikos universitetas, technologijos mokslai, informatikos inžinerija – 07T).

Oponentai:

dr. Olga Kurasova (Vilniaus universitetas, technologijos mokslai, informatikos inžinerija – 07T),

prof. habil. dr. Aleksandras Targamadzė (Kauno technologijos universitetas, technologijos mokslai, informatikos inžinerija – 07T).

Disertacija bus ginama viešame Informatikos inžinerijos mokslo krypties tarybos posėdyje 2012 m. kovo mėn. 7 d. 13 val. Vilniaus universiteto Matematikos ir informatikos instituto 203 auditorijoje.

Adresas: Akademijos g. 4, LT-08663 Vilnius, Lietuva.

Disertacijos santrauka išsiuntinėta 2012 m. vasario 5 d.

Disertaciją galima peržiūrėti Vilniaus universiteto bibliotekoje.

ABBREVIATIONS USED IN THIS SUMMARY

LM	Learning method object
LO	Learning object
MR	Methodological resource
MR1	Research Contributions
MR2	Teaching/learning planning resource
MR3	Practice generalization resource

1 INTRODUCTION

1.1 Relevance of the study

The e-learning process differs from the traditional way of learning: various aids are used (computer, mobile device, their software, network service, etc.), digital resources (documents, video, audio records, pictures and the like), the learning takes place at a convenient time and rate, independent of the place of learning. By integrating teaching and learning methods with the technologies ones we achieve flexible learning. The main peculiarity of this model is a possibility to reuse digital learning resources [TH09].

The latest research of e-learning proves that much time and efforts are necessary to create effective models improving the quality [VJG05] of learning objects (LOs) [Wil00]. On the other hand, learning takes place not only from learning resources, but also when operating, solving problems, communicating and using various means. With a view to learn, it does not suffice to present some knowledge or valuable information – only the activity of students in a proper learning environment guarantees mastering. Digital learning resources by themselves are not so valuable as their purposive application in the learning process as well as a properly selected learning method, therefore in order to find them metadata are indispensable.

A lot of methodological, didactic material has been created or is under development for traditional lessons at Lithuanian schools by using information and communication technologies (ICT) in order that students better understand the matter and develop their capabilities: to demonstrate the new material, to do laboratory works as well as individual or team work, testing, self-control and other activities. Methodological works, in which information is presented how ICTs and learning resources are used in class or in after-class activities and which teaching methods teachers apply in lesson, make up a huge resource of accumulated pedagogical experience that can be shared.

The key purpose of methodological resources is to render conditions for teachers to share the professional experience, to spread methodological novelties, to help students and their parents to join the training and learning process more actively. A free way of choosing learning methods obligates teachers to know and estimate them first of all, in line with the requirements posed to the contemporary school.

In order to reuse a resource again in another context, metadata, i.e. information assigned to describe the resource, should be related with it. That would enable us to realize LO repositories, to perform a search in them, to use LO in general, to import LO

into virtual learning environments (VLE) and to export from them, and to combine them with other objects [JK06].

Effective learning resource search and browsing possibilities can be realized only if standardized metadata are used. Metadata are the essential part of information infrastructure which is necessary with a view to help establish order in the internet chaos by using descriptions, classifications and structure which are helpful in creating more useful information repositories [Duv02].

The National LO metadata repository, created in Lithuania, is based on the LRE LOM AP v3.0 standard. However, the search present in it does not allow us to find desirable methodological resources and learning method objects, because the repository possibilities are insufficient to describe them explicitly.

In view of the mentioned methodological resource and learning method description and using aspects, the dissertation solves the following two problems typical of software engineering:

1. How to structurally describe (specify) methodological resources and teaching method objects?
2. What specific requirements should be prepared for repositories in order that methodological resources and learning methods objects were better accessible?

1.2 Research Object

The research object of this work is digital learning resources and their metadata model.

1.3 Aim and Objectives

The aim of the dissertational work is to develop an extended metadata model of digital learning resources that would cover methodological resources and learning method objects and to implement it into a prototype of the learning resource metadata repository, which will result in their increased accessibility and usage.

Objectives of the dissertation are as follows:

1. To explore standards and specifications that characterize learning resources and to reveal their merits and demerits.
2. To analyze the requirements to metadata standard applied models (application profile).
3. To consider the training and didactic conceptual models.
4. To develop an extended learning resources metadata applied model (application profile).
5. To perform an experimental approbation (estimation and feedback).
6. To implement the developed model into the LO metadata repository prototype.

1.4 Scientific novelty

1. A methodological resource is distinguished as a separate unit. Methodological resources in other repositories have not been distinguished and exhaustively explored so far.
2. A teaching/learning methods object is distinguished. These objects have not been isolated and exhaustively investigated as well so far in other repositories.

3. The developed extended model of digital learning resource metadata that allows us to structurally describe methodological resources and learning method object in metadata repositories.
4. The model enables us to realize backward relations of LOs and to present links with other LOs by the topics.
5. A template of a lesson plan, based on technologies, is proposed which allows us to automatically make up the major part of LOM elements.

1.5 Practical significance

The extended applied model of digital learning resource metadata developed in the dissertation and implemented in the prototype of LO metadata repository allows:

1. To structurally describe content LO as well as that of methodological resources and learning method objects;
2. To perform the search of digital learning resources in an LO metadata repository;
3. To increase the access to learning resources (content objects, methodological resources and learning method objects);
4. To relate content LO with methodological resources, content LO and methodological resources with learning method objects.

The proposed template of the lesson plan, based on technologies, can be useful for educators in creating and writing lesson plans because it allows us to automatically make up the major part LOM elements, which saves teachers' time and establishes conditions to do works at one place.

1.6 Statements defended

1. The developed extended learning resources metadata model allows us to describe the properties of each LO (content LO as well as that methodological resources and learning method objects), i. e. bibliographic, educational, technical and digital usage rights.
2. After implementing the extended learning resources metadata applied model in a purposively prepared LO metadata repository, accessibility to methodological resources and learning method objects has improved.

1.7 Approbation and Publications of the Research

The main results of the dissertation were published in 9 scientific papers: 4 articles in the periodical scientific publications; 5 articles in the proceedings of scientific conferences. The main results of the work have been presented and discussed at 12 national and international conferences.

1.8 Structure of the dissertation

The work consists of: glossary of terms and abbreviations, four chapters, general conclusions and results, references, and appendices. The work includes 194 pages of text, 66 figures, 34 tables and 3 appendices. The dissertation is written in Lithuanian.

Introduction of the work is presented in **Chapter 1**. Relevance of the work aim and objectives, scientific novelty, practical significance and approbation of the research are presented here.

Theoretical hypotheses, possibilities of improving the application of methodological resources and learning method objects by using an LO metadata repository are investigated in **Chapter 2**.

The created extended metadata model is described in **Chapter 3**. The process of designing the metadata applied model is described by the following stages: (1) sets of metadata elements, characterizing methodological resources and learning method objects are distinguished; (2) with a view to guarantee the metadata compatibility, controlled vocabularies are formed that are necessary to describe metadata elements; (3) a comparative analysis of metadata that describe methodological resources and learning method objects is made and an extended metadata model is developed.

Evaluation of the extended metadata model developed is presented in **Chapter 4**. The extended metadata model proposed is implemented in the LO metadata repository prototype. Experimental approbation is chosen to estimate the model, namely, engineering experiment and expert estimation of the extended metadata model.

Generalization of the results and conclusions are presented at the end.

Appendices are: glossary of LOM elements, Lithuanian – English glossary of term used in the dissertation, questionnaire of empiric research, description and results.

2 Analysis of LO peculiarities, Creation and Usage Problems

2.1 Definition of methodological resources and learning method objects and problems of their use

Based on methodological resource classification practice, methodological works in Lithuania are classified into research contributions and that helping to plan teaching and learning and the ones generalizing the experience (Fig. 1.).

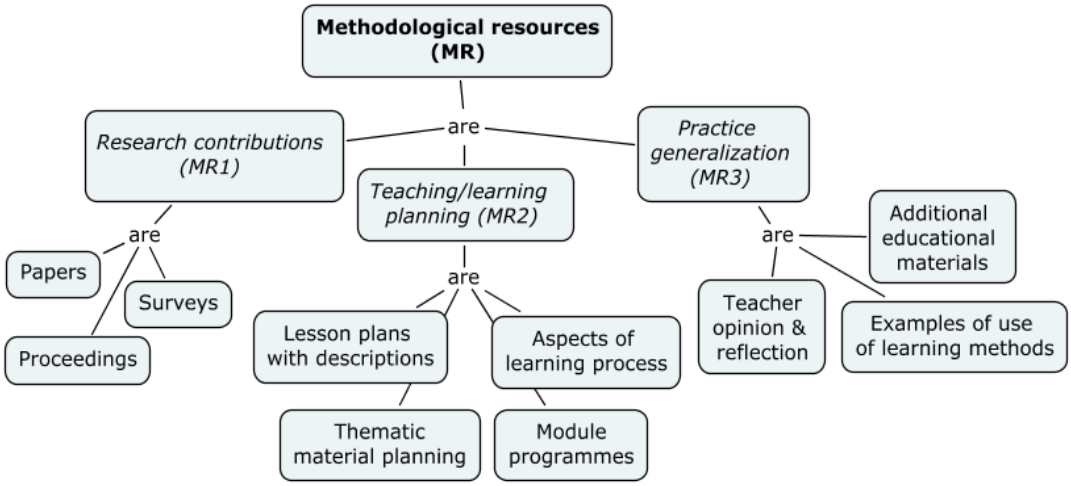

Fig. 1. The structure of methodological resources

Methodological resources (MR) provide pedagogical experience, usually addressed to other teachers, as well as descriptions, how content and learning methods LOs are used in teaching and learning processes (Fig. 1.). Usually, they can be research contributions (MR1) (e.g. methodological papers, surveys, and methodological conference proceedings), teaching/learning planning resources (MR2) (e.g. lesson plans, thematic material planning, programs of some teaching or learning modules, and aspects

of learning process), practice generalization resources (MR3) (teacher reflections and opinions, additional educational materials, and use of teaching/learning methods).

An analysis of methodological resources and learning method objects use has shown that:

1. There are specialized sites, publishing learning objects of MR1 type. Unfortunately, they are not enriched with extensive metadata to be available for search and comfortable educational use. Sometimes, access to methodological conference proceedings is denied after the conference had been held.
2. Inside some methodological resources of MR2 type (especially, lesson plans), there is a lot of meta information, i.e. data to be used to find these LOs. To be available for LO search, this information is sometimes duplicated, otherwise it is not extracted and is "hidden" inside the LO, and the search cannot benefit from it.
3. In the vast majority of MR2 (especially, lesson plans), there are descriptions and/or links to the appropriate content LOs. These content LOs are "hidden" inside the methodological LOs, and therefore, the use of those content LOs is reduced.
4. There is a great variety of MR2 type LOs and their representations. Therefore, it is difficult to automate their metadata generation.
5. There is a lack of digital teaching / learning method objects, available teaching method objects can hardly be found, since their metadata are not propagated.

2.2 Interoperability aspects of learning content and learning activities

In order that learning in an e-environment will be effective, people must have a possibility to cooperate, to use and share learning resources. Sharing resources and services is possible only if all the parts concerned have followed a clear agreement to the rules. The larger the scope of agreement, the larger the benefit. It can be realized in practice in case there exists interoperability between such different areas as the learning content and learning activity, accessibility, assessment, management and information to the learners. Various standards and specifications are used to realize these agreements. This work deals only with the following interoperability aspects of learning content and learning activities: (1) description of the content and use; (2) development of materials related to interoperability issues.

2.2.1 LO description in a formal way

The most important part of infrastructure of the information management in data repositories is metadata. In this subsection, four models of learning object metadata standards are analyzed: Learning Object Metadata (LOM), Dublin Core (DC), Machine-Readable Cataloging (MARC21) and UNIMARC. The main objective of these standards is to facilitate LO search, acquisition and use as well as to simplify sharing the teaching and learning objects, taking into consideration a variety of cultural and linguistic contexts.

A comparison of standards elements is presented in Table 1.

The survey of examples of metadata standard application in practice [DHM05] [BMR03] and others has shown that the models of DC, MARC21 and UNIMARC metadata standards are well suited for describing the bibliographical part of a digital resource, however, only partly, for the pedagogical part. Flexibility of the IEEE LOM model allows us to develop new applied information models (mandatory and freely

chosen elements are defined, vocabularies and taxonomies are used), therefore the IEEE LOM model has educational information models (Application profiles). This fact allows us to state that the LOM model is widely used in education and can reflect the peculiarities of methodological resources and teaching method objects.

Table 1. Comparison of standards elements

Description of an element	LOM elements	DC elements	MARC21 elements	UNIMARC elements
Title	General.Title (1.2)	DC.Title	245	200$a
Language of LO content	General.Language (1.3)	DC.Language	008/35-37	101
			546	
Textual description of the content of LO	General.Description (1.4)	DC.Description	500-559 except 506, 530, 540, 546	-
A keyword describing the topic of LO	General.Keyword (1.5)	DC.Subject	600, 610, 611, 630, 650, 653	606
The time, culture, region to which this LO applies.	General.Coverage (1.6)	DC.Coverage	651, 752	-
Entities that have contributed to LO creating, editing, publishing.	LifeCycle.Contribute.Entity (2.3.2)	DC.Creator	100, 110, 111, 700, 710, 711, 720	700, 710
		DC.Publisher	260ab	210$c
		DC.Contributor	-	-
Data of publishing	LifeCycle.Contribute.Date (2.3.3) as LifeCycle.Contribute.role=*Publisher*	DC.Date	260$c	210$d
Issue of LO	LifeCycle.Version (2.1)	-	-	205$a
Technical data type(s) of LO	Technical.Format (4.1)	DC.Format	856$q	215
The size of LO in bytes	Technical.Size (4.2)			
Location of LO	Technical.Location (4.3)		856$u	001
Learning Resource Type	Educational.LearningResourceType (5.2)	DC.Type	655	-
Intended end user role	Educational.IntendedEndUserRole (5.5)	DC.Audience	-	-
Context	Educational.Context (5.6)		-	-
Age of the typical intended user	Educational.TypicalAgeRange (5.7)		-	-
Description of the copyright and other restrictions	Rights.Description (6.3)	DC.Rights	506	-
Resource of which the described resource was derived	Relation.Resource as Relation.Kind = *IsBasedOn* (7.1; 7.2)	DC.Source	786ot	010, 011
Description of the related resource	Relation.Resource. Description (7.2.2)	DC.Relation	530, 760-787ot	
The topic of LO content	Classification (9.1; 9.4)	DC.Subject	600, 610, 611, 630, 650, 653	606

E. Duval [Duv02] has formulated the basic scientific and practical developing principles of LO metadata standards and their application. These are general principles

that provided suggestions for practical solutions to implement the development of semantic and syntactic interaction of any field using metadata standards.

2.2.2 Analysis of developing LO models

The subsection analyzes the issues connected with the LO creation. In order to ensure LO compatibility, multipart support of various platforms, it is necessary to create LO that would correspond to the standards.

Five development models of the content LOs have been explored: NETg Learning Object Model [LA97], Learnativity Content Model [Wag02], Sharable Content Object Reference Model (SCORM), CISCO RLO/RIO Model and General Learning Object Content Model [VD04].

LOs based on the interaction of learning activities are closely connected with the IMS Learning Design (IMS LD) specification or conceptual educational and didactic models. Five educational and didactic concept models have been analyzed, based on the interaction of learning activities: Tutorial Markup Language (TML), Educational Modeling Language (EML), PALO language [RAV04], IMS Learning Design (IMS LD), Didactical Object Model [PB06].

Based on the conceptual educational and didactic model, a structuralized, activity based object is formed in which the relation with the content LO (specified by content LO standards) is defined in a certain environment. However, the analysis has shown the reasons of diminished usage of educational and didactic conceptual models, namely: lack of environment that could use the learning design; lack of measures that could help to create a learning design; lack of concrete learning activity samples and incompatibility with the virtual learning environments.

The analysis of objects, created and described in the natural language, such as lesson plans, objects of teaching methods, has demonstrated: (1) lack of creating and description technology of a lesson plan, which has laid a basis to form a technology-based template of a lesson plan; (2) lack of generally accepted, scientifically impeccable classification of teaching methods.

Modern teaching methods are adjusted to the learning process and have the greatest influence on students' achievements [Pet08].

Implementation of learning method objects and methodological resources in a LO metadata repository can increase their accessibility, which may determine their greater usage.

3 DEVELOPMENT OF AN EXTENDED LO METADATA MODEL

The aim of this work is to develop an applied LOM model that would enable us to describe methodological resources and objects describing the learning methods, with a view to improve their accessibility and use thus giving more technological opportunities to LO users. The applied model also has to allow a description of the content LO, which means that an applied model has to be complex or extended allowing a description of all LO types.

The following methods are used for problem solving: theoretical analysis, description, synthesis.

3.1 Research of learning object search and use

In order to design an applied model, an empirical investigation of LO search and use has been performed that enabled us to estimate the reasons of diminished, supply and demand of methodological resources and teaching / learning method objects. The practice experience in training and competences of the test respondents (N=49) using ICT, were quite different, therefore after comparing the results, it has been defined that:

- Teachers called 'ICT leaders' (experienced teachers and advanced ICT users) use conference proceedings, methodological contributions and teaching method descriptions more often and much more than other teachers.
- Other teachers use, not so often, modern teaching methods that would stimulate collaboration, presentations of students individually, in pairs or groups, and their various writing activities.
- Teachers support various teaching methods classification types.

Based on the obtained results, a hypothesis has been formulated that the extended metadata model will enable us describe methodological resources and teaching method objects in the LO metadata repository and will establish conditions:

- to improve accessibility to methodological and teaching method resources, which will result in acquaintance with modern learning methods and their application examples;
- to increase the content LO use;
- to create lesson plans, using an improved template, based on technologies of lesson plan creation and description;
- to increase the competency of teachers.

It has also been defined that the relation of methodological resources with teaching / learning method should be constructive, on the one hand, and quite flexible on the other hand, therefore it is necessary to use various classification criteria.

3.2 Determination of sets of metadata elements describing MR and LM

We distinguish methodological resources and learning method objects as two separate LO subclasses. Using the classification of MR (Fig. 1.) and basing on the analysis of LO creation models, we present a diagram of LO classes (Fig. 2.). Teaching planning resources can be split into two groups: lesson plans and object founded by the interaction of activities.

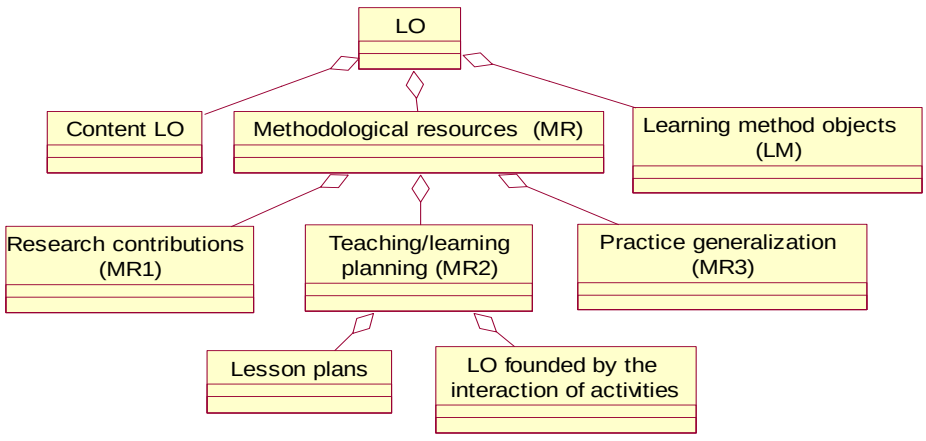

Fig. 2. Diagram of LO classes

In order that the searching mechanism (e.g. repository) search the object, each class of learning resources (Fig. 2.) has a set of elements describing it. Based on the analytical part, the sets of each LO class metadata elements have been established and represented using the LOM standard.

When describing LOs, we have to ensure the interoperability not only of different standards, but also of controlled vocabularies used [KK08a]. One of the best ways of semantic interoperability problem solving is composition of multilingual controlled vocabularies (terms and their definitions, context), of multilingual thesauri and ontologies [Kur09].

Based on the analytical part, Fig 3. presents a scheme of LO semantic relationship. LOs founded by specifications and standards are presented in rectangles: there are content LOs and teaching planning resources, grounded on learning activities. The latter rely on IMS LD specification and make up units of learning, using a certain content specification. LOs created in the natural language are presented in ovals: research contributions (MR1) (e.g. methodological papers, surveys, and methodological conference proceedings), practice generalization resources (MR3) (teacher reflections and opinions, additional educational materials, and use of teaching/learning methods), and teaching planning resources (MR2) as lesson plans. The teaching methods are also described in the natural language, - as seen from the scheme, they comprise a certain part of each LO class.

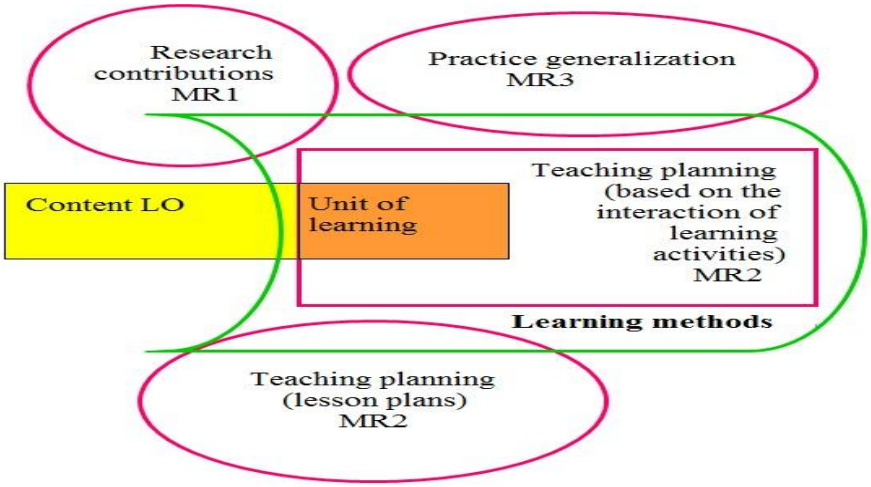

Fig. 3. The scheme of LO semantic relationship

Ontologies enable us to compile exhaustive vocabularies of notions and semantic interoperability of notions [JGV05]. Ontologies provide a systematic way of standardizing metadata elements [Puu05]. Using the OWL language we compose the LO ontology (Fig. 4.).

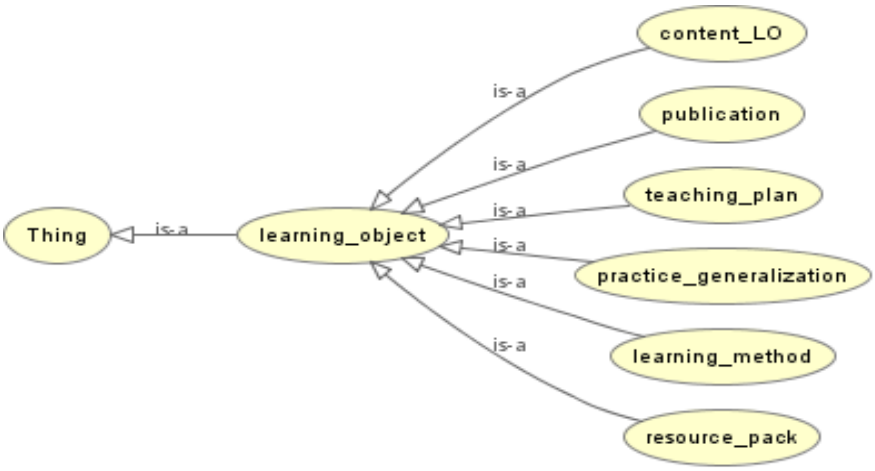

Fig. 4. LO ontology using the OWL language

The content LO, learning methods, resource pack, publication (research contributions, MR1), teaching plan and practice generalization are subclasses of the learning object class *OWL:Class*. The resource pack is an object consisting of teaching planning objects, based on learning activity interaction and content LO intersection. Using IMS LD and content LO standards, these objects comprise a unit of learning. Researched contributions are comprised of different kind and format publications.

Developers of metadata models are recommended to publish their vocabularies in the registry which would allow us to facilitate semantic interoperability and to avoid duplication [VCR03]. The comparative analysis of learning resource type vocabularies, used in the largest European projects, registered in the CEN/ISSS Application Profile Registry system and in the Vocabulary bank for Education has displayed that the Lithuanian LO metadata repository search system needs a *Learning resource type* controlled vocabulary of the LOM standard educational part 5.2 element improved and adopted to education in Lithuania.

The classification of *Learning resource types* is to be understood as the aggregate of LO classes and circumstances (Fig. 5.).

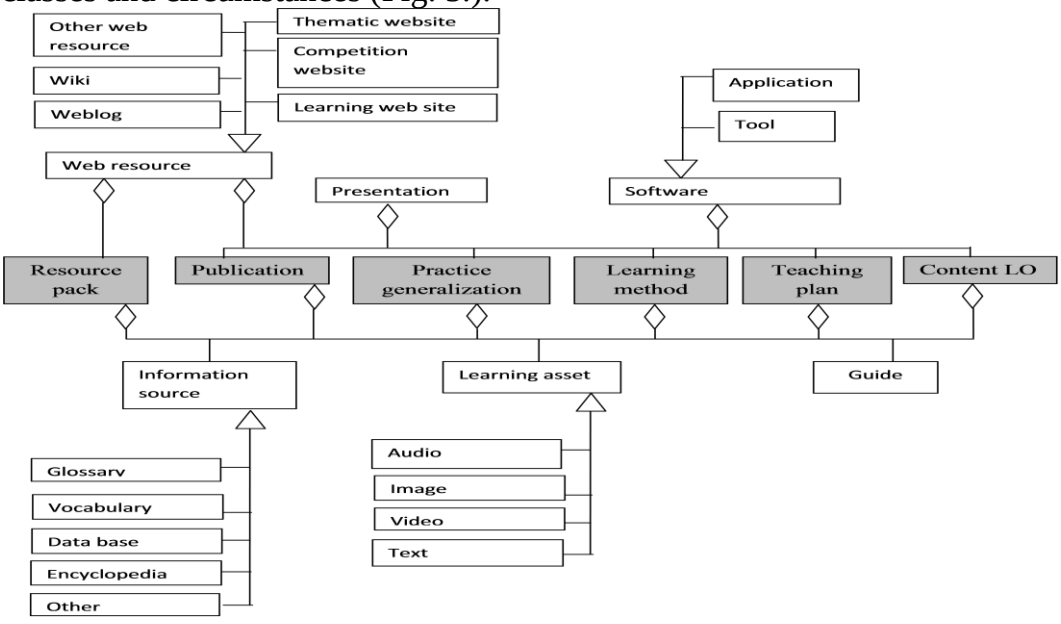

Fig. 5. Learning resource type classification,
based on the LRE *Learning resource type* controlled vocabulary

The diagram demonstrates that all entities of the marked LO classes can be comprised of learning components, they can use information sources and have a user's guide. The latter exist independently of the marked LO class entities. On the other hand, the marked LO class entities can be created and presented as internet resources or presentation. Software was used to create them. Thus, according to this classification, each LO can be easily attributed to one or more elements.

Basing on the LO ontology (Fig. 4.) and learning resource type classification (Fig. 5.), we present an improved and extended set of meanings of the LRE *Learning resource type* controlled vocabulary (Fig. 6.).

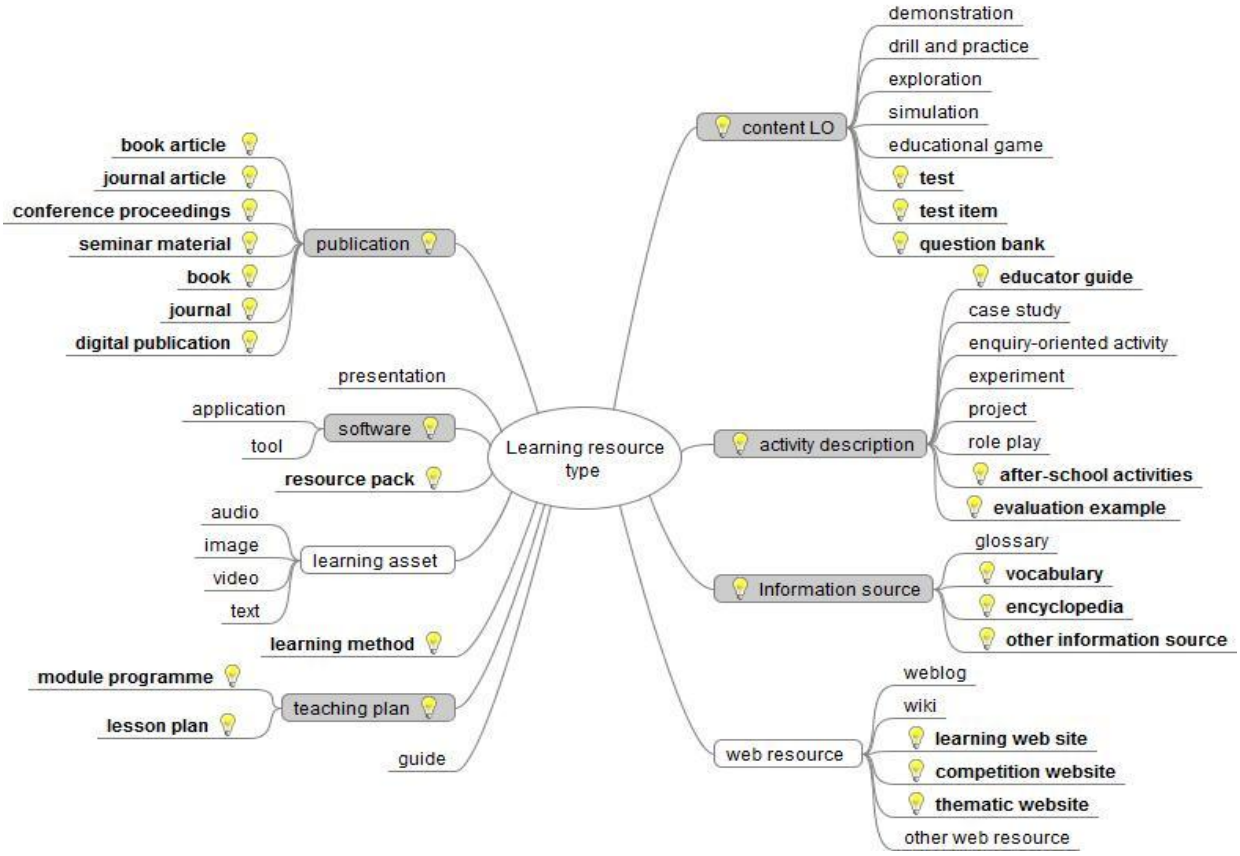

Fig. 6. A set of meanings of *Learning resource types* controlled vocabulary

The branches in this diagram express a learning resource type, and the oval shows the learning resource category. Categories and types of the LRE learning resource type controlled vocabulary are presented in unmarked branches and ovals, and improvement suggestions are represented in light and bold marked branches and ovals.

3.2.1 Proposal of a *Learning method type* controlled vocabulary

The analytical part of comparative analysis of modern learning methods has demonstrated that modern learning methods are well adapted to the learning process. Basing on these results we suggest classifying the learning methods using two criteria: the learning process phases and students' activities (Fig. 7.). In this way, the relations between the MR, the content LO and the teaching methods applied are defined more explicitly.

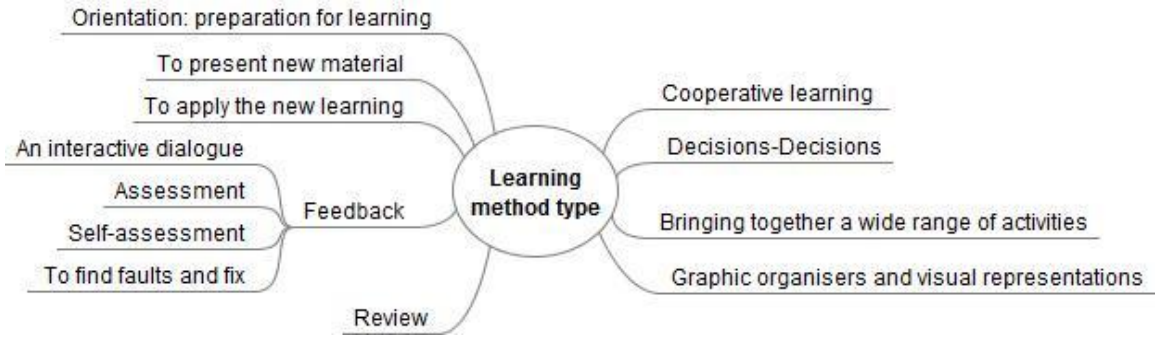

Fig. 7. A set of meanings of the *Learning method type* controlled vocabulary

The vocabulary does not cover all the students' activity types available, so only learning methods of the greatest effect are distinguished [Pet08]. Many learning methods can be attributed not only to one type of students' activities, which expands the search result a great deal. The extended search becomes inefficient and the search result can hardly comply with teachers' expectations.

On the basis of empiric analysis of the results, teachers use classifications of various learning methods, therefore the new learning method type controlled vocabulary has to embrace various classification criteria with a view to increase its flexibility (Fig. 7.).

Based on the controlled vocabulary, every method can easily be appointed to some learning phase. Thus, using the controlled vocabulary, each learning method can be attached at least to one element according to two criteria: the learning process phase and students' activity. In this way, it is possible to define a relationship between the methodological material, the content LO and the learning methods used more flexibly.

3.2.2 Importance of LO relationships for LO reuse

It is known from practice that during the creation and description of a MR teachers can: 1) describe or relate MR with the learning method, 2) associate it with content LO used in the learning process.

However, it is impossible to define objects of good experience during the creation or description of content LOs and LM, because there none of them until the latter objects come into being. That can be the reason of low use of content LOs and modern learning methods. The results of empiric research have corroborated this fact.

Automatic backward relations determination solves the problem. In order that automatic backward relation determination will be appropriate and effective, the type of relations must have an unequivocal meaning.

It is suggested to expand the LRE *Relationship Kinds* controlled vocabulary that would allow us to define the relation between the content LO, MR and LM. The expansion meanings and their notation in the LRE *Relationship Kinds* controlled vocabulary are presented in Table 2.

Table 2. Expansion of meanings of the LRE *Relationship Kinds* controlled vocabulary

Meanings of expansion in Lithuania	**Meaning in English.**	**Notation of meanings in LRE *Relationship Kinds* controlled vocabulary**
naudoja „turinio" mokymosi objektą	use „content" learning object	isrequiredby
ryšys su mokytojų gerąją patirtimi	link to teachers „good practice"	requires
naudoja mokymosi metodą	use learning method	isbasedon
mokymosi metodo taikymo pavyzdys	example of using learning method	Isbasisfor

These unique values, when showing the LO description in learning resources repository, will provide links to other LOs by topics, i. e. *Relationship Kinds*.

3.3 Extended metadata model

The results of empiric research have corroborated the hypothesis that the lack of learning method descriptions, generalized pedagogical practice, as well as lack of lesson or topic plans and lack of methodological recommendations has influence on the use of content learning objects.

Table 3. presents a comparison of sets of metadata elements that describe the LO content, methodological resources and learning method objects.

Table 3. Comparison of metadata elements

No of element	LOM element title	Content LO	MR1	MR2	MR3	LM
1.1	Identifier	+	+	+	+	+
1.2	Title	+	+	+	+	+
1.3	Language	+	+	+	+	+
1.4	Description	+	+	+	+	+
1.5	Keyword	+	+	+	+	+
1.7	Structure	+	+	+	+	+
1.8	Aggregation Level	+		+		
2.1	Version	+	+			
2.2	Status	+	+	+	+	+
2.3	Contribute	+	+	+	+	+
3.1	Identifier	+	+	+	+	+
3.2	Contribute	+	+	+	+	+
3.4	Language	+	+	+	+	+
4.1	Format	+	+	+	+	+
4.2	Size	+	+	+	+	+
4.3	Location	+	+	+	+	+
4.4	Requirement	+		+		
4.5	Installation Remarks	+		+		
4.6	Other Platform Requirements	+	+	+	+	+
4.7	Duration	+		+		
4.8	Facet	+		+		
5.1	Interactivity Type	+		+		
5.2	Learning Resource Type	Expanded and improved controlled vocabulary *LRE Learning Resource Type*				
5.3	Interactivity Level	+		+		
5.5	Intended End User Role	+	+	+	+	+
5.6	Context	+	+	+	+	+
5.7	Typical Age Range	+	+	+	+	+
5.10	Description	+	+	+	+	+
6.1	Cost	+	+	+	+	+
6.2	Copyright and Other Restrictions	+	+	+	+	+
6.3	Description	+	+	+	+	+
7.1	Kind	Improved controlled vocabulary *LOM Relationship Kinds*				
7.2	Resource	+	+	+	+	+
8	Annotation	+	+	+	+	+
9	Classification	Expanded controlled vocabulary *LOM Classification Purpose* New controlled vocabulary *Learning method type* New controlled vocabulary *Scope*				

The comparison of metadata elements illustrates that they differ from the model of LRE LOM AP v.3 in that the meanings of controlled vocabularies are improved and expanded, and two new controlled vocabularies are proposed. Metadata of each LO class comprise not the whole set of the given elements.

In order to improve the searching or browsing opportunities, when looking for methodological resources, content LOs and learning methods, it would be reasonable to change the status of some fields (see Fig. 8.).

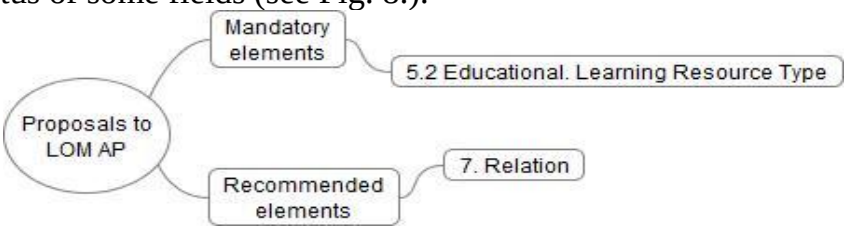

Fig. 8. Offer to change the status of fields

The change of the status of these elements, its tightening would increase a probability to find related objects of different types more rapidly and accurately.

The extended metadata model will enable us to perform the following LO regulative functions: data storing, search, technical and functional compatibility using metadata that will correlate the properties of content LO, methodological resources and learning methods objects (bibliographical, educational, technical and digital rights).

Applying the major scientific and practical principles for the development of LO metadata standards and their application profiles, on the base of the LRE LOM AP v.3 model, we propose an extended metadata model of digital learning resources, that allows us to describe content objects, methodological resources and teaching method objects. The set of all elements, given in Table 3., comprises the extended LO metadata information model. The elements in the information model are grouped into 9 categories: General, Life Cycle, Meta-Metadata, Technical, Educational, Rights, Relation, Annotation and Classification. The extended model proposed can be approved as Lithuanian LOM AP.

Extension of the LRE LOM AP v.3 model is presented in Table 4.

Table 4. Extension elements of LRE LOM AP v.3

No of element	Category Title	Element Title	Multiplicity	Data type	Reason for change or development
5.2	Educational	Learning Resource Type	0..*(10)	Extended controlled vocabulary (*LRE Learning Resource Type*)	Enables the reference to the "Learning object type" classification system
9.1	Classification	Purpose	1	Extended controlled vocabulary (*LOM Classification Purpose*)	Enables the reference to "Learning method type", "Scope", and "UDC" classification systems
9.2.2.1	Classification	Id	0..*(10)	New controlled vocabulary (*Learning method type)*	Allows us to indicate the number of ID value of the "Learning methods" vocabulary
9.2.2.2	Classification	Entry	0..*(10)	New controlled vocabulary (*Learning method type)*	Allows the reference to the learning methods used and an expanded search for content LO, learning methods, or methodological material of a selected learning method.

9.2.2.1	Classification	Id	0..*(10)	New controlled vocabulary (*Scope*)	Enables us to indicate the number of ID value of the "Scope" vocabulary
9.2.2.2	Classification	Entry	0..*(10)	New controlled vocabulary (*Scope*)	Allows us to indicate the number of learners (group size) the activity is designed for (e. g. individual activity, work in pairs, work in groups, whole-class activity).
7.1	Relation	Kind	0..1	Extended controlled vocabulary (*LOM Relationship Kinds*)	Enables us to indicate unique values to establish an automatic relation between LOs

The extended meanings of the LOM *Classification Purpose* controlled vocabulary are given in Table 5.

Table 5. Extension of the LOM *Classification Purpose* controlled vocabulary

Meanings of expansion in English	Meanings in Lithuania
learning methods types	mokymosi metodų tipai
Scope	grupės dydis
UDC	UDK

Meanings of the new controlled vocabulary *Scope* are given in Fig. 9.

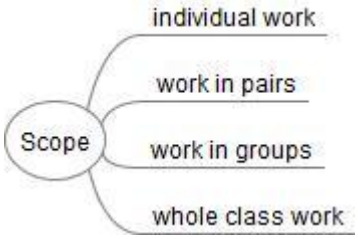

Fig. 9. Meanings of the controlled vocabulary *Scope*

4 EXPERIMENTAL APPROBATION OF THE LO METADATA APPLIED MODEL

4.1 Implementation of the extended LO metadata model into a prototype

In this part of chapter, implementation of the extended digital learning resource metadata model into the prototype of the LO metadata repository is presented. Our aim is to show the result obtained: the extended model created enables us to define MR and LM in a structuralized way, facilitates the accessibility to the abovementioned objects and establishes conditions to increase their use as well as the use of content LO.

The extended LO metadata model is implemented in the LO metadata repository prototype[1], that was developed on the basis of the Education portal LO metadata repository[2]. The author of this dissertation took part in the work of designing and exploiting this repository. The following components are implemented in the prototype: new controlled vocabulary *Leraning methods types*, new controlled vocabulary *Group size*, improved and expanded controlled vocabulary LRE *Learning resource types*, expanded controlled vocabulary LOM *Classifikation Purpose*, expanded controlled vocabulary LOM *Relationship Kinds*, determination mechanism of backward relation between LOs.

[1] http://lom2.emokykla.lt/public/ - LO metadata repository prototype
[2] http://lom.emokykla.lt/public/ - LO metadata repository of Education portal

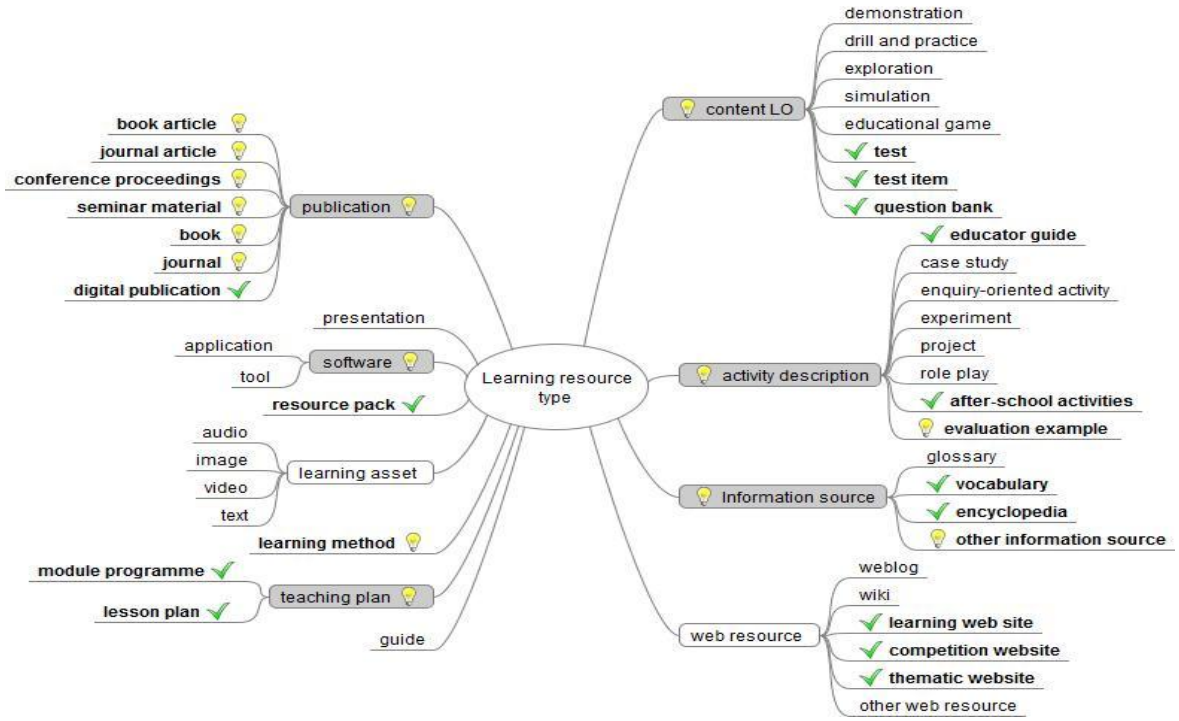

Fig. 10. Implementation of the controlled vocabulary *Learning resource types*

Proposals of the *Learning resource type* denoted by a tick are approved of Director of Centre of Information Technologies in Education by order No V1-175, December 6, 2010, and implemented in the LO metadata repository of Education portal. Proposals denoted by a "bulb" and that in the grey background ovals are implemented only in the LO metadata prototype (Fig. 10.).

An expanded part of the controlled vocabulary LOM *Relationship Kinds* is approved by the good practice".

Since January 2011, the determination mechanism of backward relations between Los has been implemented in LO metadata repository of Education portal and an automatic relation of the content LO with MR has been realized.

4.2 Experimental approbation

At present, the LO metadata repository prototype lacks some metadata that would allow us to carry out full rate engineering experiments. Pilot metadata of MR and LM are created in the prototype that enables the trial of prototype action. The working results were explored empirically in addition.

Fig. 11. presents an example of the metadata part of the learning method object in which we see a backward relation with the lesson plan to which learning method type it belongs, and in which student group the learning method is applied.

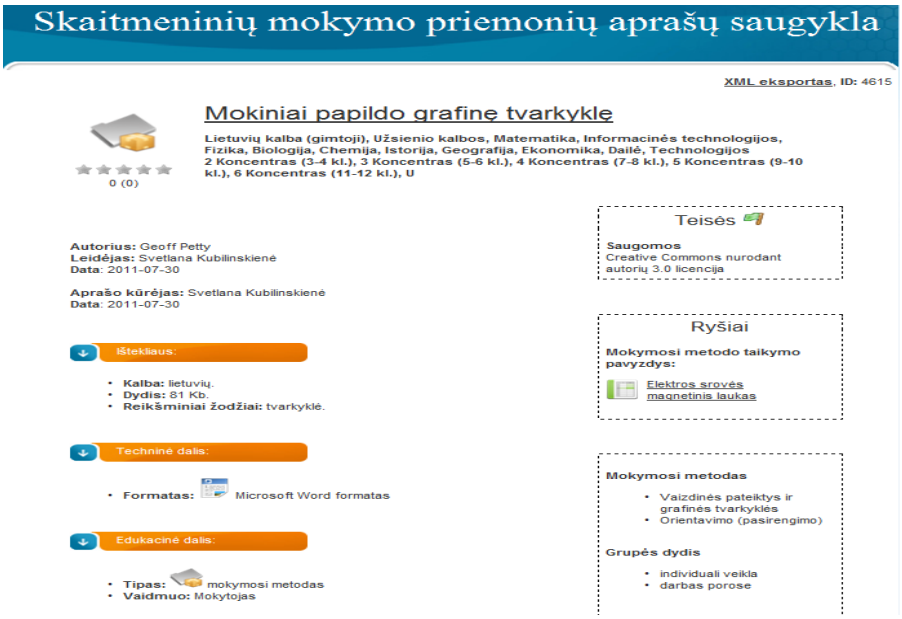

Fig. 11. A metadata part of the learning method object

In order to determine how much the metadata model proposed allows a more efficient and accurate LO search (which opens opportunities to get acquainted with Los and use them in practice) and a compensation of engineering experiment, the interview of experts has been taken.

Educators "ICT leaders", who have a high ICT competence for use in training and are of the highest qualification category of Lithuanian teachers – expert teacher, were selected for polling. With a view to achieve reliable and accurate results of the proposed model estimation, 4 experts were selected who met the proficiency requirements (no less than 7 year experience in the ICT leaders programmer; an active member of an innovator teachers' group; created no less than 5 LO descriptions in an LO metadata or some other repository where the standardized LO description is implement; has a teacher-expert category and published at least 3 methodological publications in the field of ICT application to education).

The interview consisted of 8 questions to estimate the possibilities for search of digital learning resources in an LO metadata repository where LRE LOM AP v.3.0 standard was implemented as well as of the prototype of an LO metadata repository, in which the model, proposed in this work, has been implemented. The ninth question was open, meant for general remarks on the model proposed here.

Table 6. presents the study aspects and the respective question to experts from the interview before and after the LO metadata model implementation as well as the formula by which we can evaluate how many times the search result possibility has diminished or increased.

Table 6. Use of the answers to evaluate the study aspect

Question	Study aspect	Estimation (before)	Estimation (after)	Formula
Q1	Possibility to find descriptions of methodological publications (article, journal, conference proceedings)	a1	b1	b1/a1
Q2	Possibility to find descriptions of	a2	b2	b2/a2

	competitions, olympiads websites			
Q3	Possibility to find descriptions of the content LO	a3	b3	b3/a3
Q4	Possibility to find descriptions of the content LO in which has a reference to application examples (MR)	a4	b4	b4/a4
Q5	Possibility to find descriptions of the MR (e. g. educator's guide)	a5	b5	b5/a5
Q6	Possibility to find descriptions of the MR (e. g. educator's guide) in which has a reference to the content LO	a6	b6	b6/a6
Q7	Possibility to find descriptions of the MR (e. g. educator's guide) in which has a reference description of an applied learning method	a7	b7	b7/a7
Q8	Possibility to find descriptions of a learning method object	a8	b8	b8/a8

To estimate the study aspect, the following estimation scale was given:

1 – Failed to find;
2 – Hardly found;
3 – Found;
4 – Easily found.

On the basis of the experts' answers to questions Q1–Q8 and the formula in Table 6., the final estimates are as follows (Table 7.):

Table 7. Estimates of the study aspects, based on the experts' answers

Q	Expert A	Expert B	Expert C	Expert D	Average	Standard deviation
Q1	2	1,5	3	3	2,37	0,75
Q2	3	1,5	1,5	1,5	1,87	0,75
Q3	1,33	1,33	1,33	1,33	1,33	0
Q4	2	2	1,5	3	2,12	0,62
Q5	1,33	1,33	1,33	2	1,49	0,33
Q6	1,33	1,33	2	2	1,66	0,38
Q7	1,5	3	3	3	2,62	0,75
Q8	3	3	3	3	3	0

Remarks of the experts about the implementation of the LO metadata model are positive in essence. There are some remarks as to a successful use of the LO repository: the issues of complementation of the available descriptions and appearance of new descriptions.

The estimates of study aspects of each expert and the estimate average of each study aspect are illustrated graphically in Fig. 12.

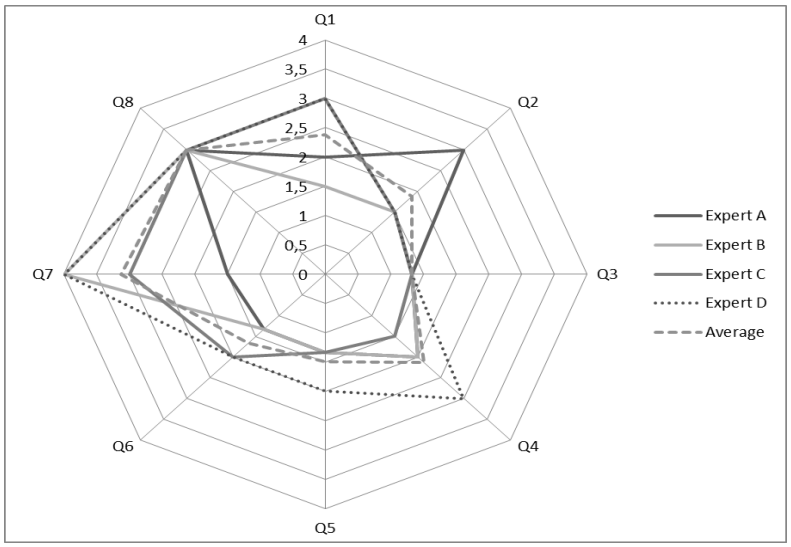

Fig. 12. Expert estimations

When generalizing we rely on the average meanings of expert estimations and will calculate how much more efficiently and exactly the LO metadata repository prototype enables as to perform the LO search after implementing the LO metadata model:

$$\sum_{i=1}^{8} x_i = 2{,}0615,\ \text{SD}\ 0{,}57$$

Basing on the expert estimates we see that the LO metadata model, proposed in this research work, enables us to find digital learning resources (content LO's, methodological resources, learning method objects) two times more efficiently and accurately in the LO metadata repository prototype where LRE LOM APv3.0 is implemented.

GENERAL CONCLUSIONS AND RESULTS

1. The analysis of literature shows that the methods and means are necessary that would ensure a more efficient description of methodological resources and teaching/learning method objects metadata and their search.
2. After considering the metadata standard models LEEE LOM, DC, MARC21 and UNIMARC that can describe methodological resources and teaching/learning method objects and after making their comparative analysis, we have defined that the IEEE LOM model is most suitable to describe the peculiarities of methodological resources and teaching/learning method objects.
3. The empirical research of LO search and use has shown that: (1) relationship of methodological resources with teaching/learning method objects should be constructive, on the one hand, and quite flexible on the other hand, therefore it is necessary to use various classification criteria; (2) dependence of LOs usage and their demand on educators' competencies has been revealed.
4. With the help of the LO semantic relationship scheme presented in this work, a general LO ontology was composed: six major LO classes have been formed and distinguished.

5. Basing on the comparative analysis of the content LO, methodological resources and on metadata elements describing teaching methods as well as on scientific and practical principles for developing LO metadata standard application models, we propose an extended digital learning resource metadata model on the basis of the LRE LOM AP v.3.0 models. The main properties of the model proposed are as follows: (1) a possibility for structural description of content objects, methodological resource and method objects has been offered; (2) the means to automatically implement a backward LO relation have been created which enables us to present the relationship with other LOs by topics.
6. Our work has defined that the expanded model proposed here differs from the LRE LOM AP v.3 model in that it has improved and extended the meanings of 3 controlled vocabularies and proposed 2 new controlled vocabularies.
7. Based on the LOM standard and identified lesson plan components, a technology-based template of a lesson plan, has been proposed which allows us to automatically make up the major part of LOM elements.
8. After the expert evaluation of the LO metadata model proposed, it has been determined that the metadata model enables us to perform LO search approximately two times more rapidly and exactly, i. e. the accessibility and use of methodological resources and teaching/learning method objects has increased.
9. The proposed extended digital learning resource metadata model is significant both in the theoretical informatics engineering aspect (it can give structural metadata to the recently distinguished two learning resource types) and in practical application (it increases the efficiency and accuracy of learning resource search, and offers thereby more favorable conditions to increase educators competences).

LIST OF LITERATURE, REFERENCED IN THIS SUMMARY

[BMR03] Barbosa, E. F., Maldonado J. C., Ricarte I. L. M. Exploring Learning Objects under Conceptual, Instructional and Didactic Perspectives. In *Proceedings of the I PGL Database Research Conference* (PGLDB 2003), Rio de Janeiro, Brazil, April 10-11, 2003. http://CEUR-WS.org/Vol-70/ [Accessed on 2011-12-12]

[DHM05] Dahlquist, G., Hoffman, B., Millman, D. Integrating digital libraries and electronic publishing in the DART project. In *Proceedings of the 5th ACM/IEEE-CS Joint Conference on. Digital Libraries*, 2005. JCDL '05, 7-11 June 2005, p. 114 – 120.

[Duv02] Duval, E. et al. Metadata Principles and Practicalities. In *D-lib Magazine*, vol 8, Number 4, 2002. ISSN 1082-9873, p. 1-16.

[JGV05] Jovanovic, J., Gaševic, D., Verbert, K., Duval, E. (2005). Ontology of learning object content structure, In *Proceedings of the 12th International Conference on Artificial Intelligence in Education*, Amsterdam, 2005.

[JK06] Jevsikova, T., Kurilovas, E. European Learning Resource Exchange: Policy and Practice. In *Proceedings of the 2nd International Conference on*

Informatics in Secondary Schools: Evolution and Perspectives. Vilnius, Lithuania, 7–11 November 2006. Selected papers, TEV, p. 670–676.

[KK08a] Kurilovas, E., Kubilinskienė, S. (2008). Interoperability Framework for Components of Digital Library of Educational Resources and Services. *Informacijos mokslai.* Vilnius, 2008, Vol. 44, p. 88–97.

[Kur09] Kurilovas, E. (2009). Learning Objects Reusability and Their Adaptation for Blended Learning. In *Proceedings of the 5th International Conference on Networking and Services* (ICNS 2009). April 20-25, 2009 – Valencia, Spain, p. 542–547. ISBN 978-0-7695-3586-9 [IARIA] [IEEE Xplore Digital Library] [Thomson ISI Proceedings].

[LA97] L'Allier, J. J. A Frame of Reference: NETg's Map to Its Products, Their Structures and Core Beliefs. NetG Whitepaper, 1997. http://www.elearning learning.com/ [Accessed on 2011-09-13]

[PB06] Pawlowski, J. M., Bick, M. Managing & re-using didactical expertise: The Didactical Object Model. *Educational Technology & Society*, 2006, 9 (1), p. 84-96.

[Pet08] Petty, G. Įrodymais pagrįstas mokymas: praktinis vadovas. – Vilnius: Tyto alba, 2008.

[Puu05] Puustjarvi, J. Using metadata in learning networks. *Fifth IEEE International Conference on Advanced Learning Technologies* (ICALT 2005), 2005, p. 903 – 905.

[RAV04] Rodríguez-Artacho, M., Verdejo Maíllo, M. F. Modeling Educational Content: The Cognitive Approach of the PALO Language. *Educational Technology & Society*, 2004, Issue 3, p. 124-137.

[TH09] Tate, M., Hoshek, D. A Model for the Effective Management of Re-Usable Learning Objects. *Interdisciplinary Journal of E-Learning and Learning Objects.* Vol. 5, 2009.

[VCR03] Van Assche, F., Campbell, L.M., Rifon, L.A., Willem, M. Semantic interoperability: use of vocabularies with learning object metadata. In *Proceedings of the 3rd IEEE International Conference on Advanced Learning Technologies*. 2003, p. 511 – 514.

[VD04] Verbert, K., Duval, E. Towards a Global Component Architecture for Learning Objects: A Comparative Analysis of Learning Object Content Models. In *Proceedings of the World Conference on Educational Multimedia, Hypermedia and Telecommunications* (ED-MEDIA). 2004, p. 202-208.

[VJG05] Verbert K., Jovanovic, J., Gaševic, D., Duval, E., Meire, M. Towards a Clobal Component Architechture for Learning Objects: a slide Presentation Framework. In *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications*. 2005, p. 1429-1436.

[Wag02] Wagner, E. D. Steps to Creating a Content Strategy for Your Organization. *The e-Learning Developers' Journal*, October 2002.

[Wil00] Wiley, D. Connecting Learning Objects to Instructional design Theory: a definition, a Metaphor, and a Taxonomy. Utah State University, 2000. http://www.reusability.org/read/ [Accessed on 2011-09-13]

LIST OF PUBLICATIONS ON THE SUBJECT OF DISSERTATION

Articles in peer-reviewed periodical journals:

1. Kubilinskienė, S.; Dagienė V. Technology-based Lesson Plans: Preparation and Description // Informatics in Education. 2010, vol. 9, no. 2, p. 217-228. ISSN 1648-5831.
2. Kubilinskienė, S.; Dagienė, V. Pamokų planų šablonai: analizė ir technologijų taikymas // Lietuvos matematikos rinkinys. Lietuvos matematikų draugijos darbai. 2010, T. 51, p. 115–120. ISSN 0132-2818.
3. Kubilinskienė, S.; Žilinskienė, I. Mokymosi objektų metaduomenų analizė: valdomų žodynų reikšmės // Informacijos mokslai. Kaunas, 2009, Vol. 50, p. 95-100. ISSN 1392-0561.
4. Kurilovas, E.; Kubilinskienė, S. Interoperability Framework for Components of Digital Library of Educational Resources and Services // Informacijos mokslai. Vilnius, 2008, Vol. 44, p. 88–97. ISSN 1392-0561

Articles, published in other reviewed publications:

1. Kubilinskienė, S; Kurilovas, E. Lithuanian Learning Objects Technical Evaluation Tool and its Application in Learning Object Metadata Repository // Informatics Education Contributing Across the Curriculum: the third International Conference –ISSEP 2008, Informatics in Secondary Schools – Evolution and Perspective. Torun, Poland, July 1 – 4, 2008. Selected papers, p. 147 – 158. ISBN 978-83-60425-31-2.
2. Kurilovas, E.; Kubilinskienė, S. Interoperability guidelines for digital library of educational resources and services // WEBIST 2008: Proceedings of the Fourth International Conference on Web Information Systems and Technologies. Funchal, Madeira, Portugal, 4–7 May, 2008. Selected papers, p. 468-471. ISSN 0302-9743.
3. Kurilovas, E.; Kubilinskienė, S. Analysis of Lithuanian LOM Repository Strategies, Standards and Interoperability // Proceedings of the Second International Workshop on Search and Exchange of e-learning Materials (SE@M'08). Maastricht, Netherlands, 17 – 19 September, 2008. CEUR Workshop proceedings, Vol. 385. Available from Internet: <http://sunsite.informatik.rwth-aachen.de/Publications/CEUR-WS/Vol-385/>, ISSN 1613–0073.
4. Kurilovas, E.; Kubilinskienė, S. Creation of Lithuanian Digital Library of Educational Resources and Services: the Hypothesis, Contemporary Practice, and Future Objectives // LODE'07: Proceedings of the 1st International Workshop on Learning Object Discovery & Exchange. Sissi, Crete, Greece, 17–20 September, 2007. CEUR Workshop proceedings, Vol. 311, p. 11–15. Available from Internet: <http://CEUR-WS.org/Vol-311/>, ISSN 1613-0073.
5. Kurilovas, E.; Kubilinskienė, S. E-mokymosi turinio semantinis sąveikumas: problema ir praktiniai sprendimai // Informacinės technologijos: konferencijos pranešimų medžiaga. Kauno technologijos universitetas, Kaunas, 2007 m. sausio 31 d. – vasario 1 d., p. 102-106. ISSN 1822-6337.

SHORT DESCRIPTION ABOUT THE AUTHOR

Svetlana Kubilinskienė received the qualification of a physics, astronomy and informatics teacher at comprehensive schools from the Lithuanian University of Educational Sciences (former Vilnius Pedagogical University) in 1995 and a Master's degree in mathematics and the qualification of a mathematics and informatics teacher at high schools in 1996. During the period of 2007–2011 she was a PhD student at Vilnius University Institute of Mathematics and Informatics (technological sciences, informatics engineering). Since 1995 she has been working at the Centre of Information Technologies in Education, responsible for the Lithuanian national LO metadata repository, its design and development. Her research interests include the management and reuse of digital learning resources, metadata specification and standards, development of learning object and related software, learning management systems and environments.

SANTRAUKA

Darbo aktualumas

Elektroninio mokymo(si) procesas skiriasi nuo tradicinio mokymo(si) būdo: naudojamos įvairios priemonės (kompiuteris, mobilusis įrenginys, jų programinė įranga, tinklo paslaugos ir t. t.), skaitmeniniai ištekliai (dokumentai, vaizdo, garso įrašai, nuotraukos ir pan.), mokomasi patogiu laiku ir tempu, nepriklausomai nuo mokymo(si)si vietos. Tradicinius mokymo ir mokymosi metodus integruojant su elektroniniais gaunamas lankstusis mokymasis. Svarbiausia šio modelio ypatybė – galimybė pakartotinai naudoti skaitmeninius mokymo(si) išteklius [TH09].

Naujausi el. mokymo(si) tyrimai rodo, kad reikia daug laiko ir pastangų, norint sukurti efektyvius modelius, gerinant mokymo(si) objektų [Wil00] kokybę [VJG05]. Antra vertus, mokymasis vyksta ne tik iš mokymo(si) išteklių, bet ir veikiant, sprendžiant problemas, bendraujant, naudojantis įvairiomis priemonėmis. Norint išmokti neužtenka pateikti žinių ar vertingos informacijos – tik mokinių veikla tinkamoje mokymo(si) aplinkoje užtikrina išmokimą. Skaitmeniniai mokymo(si) ištekliai patys savaime nėra tiek vertingi, kiek jų tikslingas taikymas per mokymo(si) procesą ir teisingai parinktas mokymo(si) metodas, – todėl, norint rasti pastaruosius, būtini jų metaaprašai.

Lietuvoje sukurta ir kuriama nemažai metodinės, didaktinės medžiagos tradicinėms pamokoms mokykloje, kai naudojamos informacinės ir komunikacinės technologijos (toliau – IKT), siekiant gerinti mokinių medžiagos supratimą ir gebėjimų lavinimą: naujai medžiagai demonstruoti, laboratoriniams darbams vykdyti, individualiam ir grupiniam darbui, testavimui, savikontrolei ir kitai veiklai. Metodiniai darbai, kuriuose pateikiama informacijos, kaip naudojamos IKT ir mokymo(si) objektai per pamokas ar užklasinę veiklą, kokius mokymo(si) metodus pedagogai taiko per pamoką, yra vertingas ir gausus pedagogų sukauptos patirties šaltinis, kuriuo galima dalytis.

Pagrindinė metodinių darbų (išteklių) paskirtis – suteikti mokytojams galimybę dalytis profesine patirtimi, skleisti metodines naujoves, padėti mokiniams ir jų tėvams aktyviau įsilieti į ugdymo ir ugdymo(si) procesą. Laisvė rinktis mokymo(si) metodus

įpareigoja mokytojus pirmiausia juos žinoti ir vertinti remiantis šių dienų mokyklai keliamais reikalavimais.

Norint išteklių panaudoti iš naujo, kitame kontekste, su juo turi būti susieta ištekliui aprašyti skirta informacija – metaduomenys. Tai leistų realizuoti MO saugyklas, jose atlikti paiešką, bendrai naudoti MO, importuoti MO į virtualiąsias mokymo(si) aplinkas (toliau – VMA) ir eksportuoti iš jų, komponuoti su kitais objektais [JK06].

Efektyvios mokymo(si) išteklių paieškos ir naršymo galimybės gali būti įgyvendintos tik tada, kai bus naudojami standartizuoti metaduomenys. Metaduomenys yra svarbiausia informacijos infrastruktūros dalis, kuri būtina siekiant padėti sukurti tvarką interneto chaose, naudojant aprašus, klasifikacijas ir struktūrą, kurie padeda sukurti naudingesnes informacijos saugyklas [Duv02].

Lietuvoje sukurta nacionalinė mokymo(si) objektų metaduomenų saugykla, pagrįsta LRE LOM AP v3.0 MO metaduomenų standartu. Tačiau joje esanti paieška neleidžia rasti pageidaujamų metodinių išteklių ir mokymo(si) metodų objektų, nes saugyklos galimybės neleidžia jų tikslingai aprašyti.

Atsižvelgus į minėtus metodinių išteklių ir mokymo(si) metodų aprašymo ir naudojimo aspektus, disertaciniame darbe sprendžiamos šios dvi programinės įrangos inžinerijai būdingos problemos:

1. Kaip struktūrizuotai aprašyti (specifikuoti) metodinius išteklius ir mokymo(si) metodų objektus?
2. Kokius specifinius reikalavimus reikia parengti saugykloms, kad metodiniai ištekliai ir mokymo(si) metodų objektai būtų lengviau randami?

Darbo objektas

Šio darbo tyrimo objektas – skaitmeniniai mokymo(si) ištekliai ir jų metaduomenų modelis.

Darbo tikslas

Siekiant padidinti metodinių išteklių ir mokymo(si) metodų objektų pasiekiamumą ir naudojimą, sukurti ir įdiegti į mokymo(si) išteklių metaduomenų saugyklos prototipą – išplėstą skaitmeninių mokymo(si) išteklių metaduomenų modelį, kuris apimtų metodinius išteklius ir mokymo(si) metodų objektus.

Darbo uždaviniai

1. Ištirti standartus ir specifikacijas, apibūdinančias mokymo(si) išteklius, atskleisti jų privalumus ir trūkumus.
2. Išanalizuoti reikalavimus metaduomenų standartų taikomiesiems modeliams.
3. Išnagrinėti ugdymo ir didaktinius koncepcinius modelius.
4. Sukurti išplėstą mokymo(si) išteklių metaduomenų taikomąjį modelį (*aplication profile*).
5. Atlikti modelio eksperimentinį aprobavimą (įvertinimas ir grįžtamasis ryšys).
6. Įdiegti sukurtąjį modelį į MO metaduomenų saugyklos prototipą.

Mokslinis naujumas

Pagrindiniai disertacinio darbo naujumo aspektai:

1. Kaip atskiras vienetas išskirtas metodinis išteklius. Metodiniai ištekliai kitose saugyklose iki šiol nebuvo išskiriami ir išsamiau tyrinėjami.

2. Išskirtas mokymo(si) metodų objektas. Mokymo(si) metodų objektai kitose saugyklose iki šiol taip pat nebuvo išskirti ir išsamiau tyrinėjami.
3. Sukurtas išplėstas skaitmeninių mokymo(si) išteklių metaduomenų modelis, leidžiantis struktūrizuotai aprašyti metodinius išteklius ir mokymo(si) metodų objektus metaduomenų saugyklose.
4. Modelis leidžia automatiškai realizuoti atgalinius mokymo(si) objektų ryšius ir įgalina pateikti sąsajas su kitais mokymo(si) objektais pagal tematiką.
5. Pasiūlytas technologijomis grindžiamas pamokos plano šablonas, leidžiantis automatiškai užpildyti didesnę LOM elementų dalį.

Praktinė darbo reikšmė

Darbe sukurtas ir įdiegtas MO metaduomenų saugyklos prototipe išplėstas skaitmeninių mokymo(si) išteklių metaduomenų taikomasis modelis, leidžiantis:

1. struktūrizuotai aprašyti turinio objektus, metodinių išteklių ir mokymo(si) metodų objektus;
2. atlikti skaitmeninių mokymo(si) išteklių paiešką MO metaduomenų saugykloje;
3. padidinti prieigą prie mokymo(si) išteklių (turinio MO, metodinių išteklių, mokymo(si) metodų objektų);
4. susieti turinio mokymo(si) objektus su metodiniais ištekliais, turinio mokymo(si) objektus ir metodinius išteklius su mokymo(si) metodų objektais.

Siūlomas technologijomis grindžiamas pamokos plano šablonas gali būti naudingas pedagogams kuriant ir aprašant pamokos planus, nes leidžia automatiškai užpildyti didesnę LOM elementų dalį, tai taupo pedagogų laiką ir sudaro sąlygas darbus atlikti vienoje vietoje.

Ginamieji teiginiai

1. Sukurtas išplėstas mokymo(si) išteklių metaduomenų modelis leidžia aprašyti kiekvieno MO (turinio MO, metodinių išteklių ir mokymo(si) metodų objektų) savybes, t.y. bibliografines, edukacines, technines ir skaitmeninio naudojimo teises.
2. Įdiegus išplėstą mokymo(si) išteklių metaduomenų taikomąjį modelį, tikslingai parengtoje MO metaduomenų saugykloje, pagerėjo metodinių išteklių ir mokymo(si) metodų objektų pasiekiamumas.

Aprobavimas ir publikavimas

Disertacijos rezultatai publikuoti 9 moksliniuose leidiniuose: 4 periodiniuose recenzuojamuose mokslo žurnaluose, 5 straipsniai konferencijų pranešimų medžiagoje. Tyrimų rezultatai pristatyti 12 užsienio ir Lietuvos konferencijų.

Darbo struktūra

Darbą sudaro: terminų ir santrumpų žodynas, keturios pagrindinės dalys – skyriai, išvados ir rezultatai, naudotos literatūros sąrašas ir priedai. Darbo apimtis yra 194 puslapiai. Tekste panaudoti 66 paveikslų, 34 lentelės ir 3 priedai. Rašant disertaciją buvo naudotasi 100 literatūros šaltinių.

Pirmajame skyriuje pateikiamas darbo įvadas. Pristatomas darbo aktualumas, darbo tikslai ir uždaviniai, mokslinis naujumas, praktinė darbo reikšmė ir darbo aprobavimas.

Antrajame skyriuje nagrinėjamos teorinės darbo prielaidos, metodinių išteklių ir mokymo(si) metodų naudojimo gerinimo galimybės naudojant MO metaduomenų saugyklą. Tam skyriaus antroje dalyje išanalizuotos MO ypatybės: metodinių išteklių ir mokymo(si) metodų objektų apibrėžtis ir jų naudojimo problemos, mokymo(si) metodų klasifikavimo problema. Apžvelgiami standartai ir specifikacijos, apibūdinančios mokymo(si) objektus, atskleisti jų privalumai ir trūkumai. Analizuojami taikymo modelių sudarymo reikalavimai, apžvelgti su medžiagos kūrimu susiję sąveikos klausimai: turinio MO kūrimo modeliai, mokymo(si) veiklų sąveika grįsti MO modeliai, pamokos planų kūrimo scenarijai.

Metodinių išteklių ir mokymo(si) metodų objektų pasiekiamumą ir naudojimą galima gerinti panaudojant tikslingai parengtą MO metaduomenų saugyklą. Šis sprendžiamas uždavinis aprašomas trečiajame skyriuje. Antrojo skyriaus pabaigoje pateikiama esamos Lietuvos MO metaduomenų saugyklos apžvalga.

Trečiajame skyriuje aprašomas sukurtas išplėstas metaduomenų modelis. Tam pradžioje atliekamas mokymo(si) objektų paieškos ir naudojimo tyrimas, kuris leidžia įvertinti metodinių išteklių ir mokymo(si) metodų objektų pasiūlos, paklausos, mažo naudojimo priežastis. Metaduomenų taikomojo modelio projektavimo procesas aprašomas tokiais etapais: 1) išskirtos metodinių išteklių ir mokymo(si) metodų objektų aprašančių metaduomenų elementų aibės; 2) siekiant užtikrinti metaduomenų suderinamumą suformuoti valdomieji žodynai, reikalingi metaduomenų elementams aprašyti; tam sukurta bendra mokymo(si) objektų ontologija ir išskirtos pagrindinės mokymo(si) objektų klasės, atlikta *Mokymosi ištekliaus tipo* valdomųjų žodynų lyginamoji analizė, šiuolaikinių mokymo(si) metodų klasifikacijų lyginamoji analizė, parodyta MO ryšių svarba daugkartiniam naudojimui; 3) atlikta metodinių išteklių ir mokymo(si) metodų objektų aprašančių metaduomenų lyginamoji analizė ir sukurtas išplėstas metaduomenų modelis.

Ketvirtajame skyriuje pateikiamas sukurto išplėsto metaduomenų modelio vertinimas. Tuo tikslu pasiūlytas išplėstas metaduomenų modelis įdiegtas į MO metaduomenų saugyklos prototipą. Modeliui įvertinti pasirinktas eksperimentinis aprobavimas: inžinerinis eksperimentas ir ekspertinis išplėsto metaduomenų modelio vertinimas.

Darbo pabaigoje pateikiamas rezultatų apibendrinimas ir išvados.

Prieduose pateikiama: LOM elementų žodynėlis, disertacijoje vartojamų terminų lietuvių – anglų kalbų žodynėlis, empirinio tyrimo anketa, aprašymas ir rezultatai.

Bendrosios išvados ir rezultatai

1. Atlikta literatūros analizė rodo, kad reikalingi būdai ir priemonės, kurie užtikrintų efektyvų metodinių išteklių ir mokymo(si) metodų metaduomenų aprašymą ir jų paiešką.
2. Išanalizavus metaduomenų standartų modelius IEEE LOM, DC, MARC21 ir UNIMARC, galinčius aprašyti metodinius išteklius ir mokymo(si) metodų objektus, atlikus jų lyginamąją analizę, nustatyta, kad metodinių išteklių ypatumams aprašyti labiausiai tinka IEEE LOM modelis.
3. Atliktas empirinis tyrimas parodė, kad: (1) metodinių išteklių ryšys su mokymo(si) metodais turėtų būti, iš vienos pusės, konstruktyvus, iš kitos –

pakankamai lankstus, todėl būtina naudoti įvairius mokymo(si) metodų klasifikavimo kriterijus; (2) išryškintas MO naudojimo ir jų paklausos priklausomybė nuo pedagogų kompetencijų.

4. Pateikta MO semantinio ryšio schema leido sudaryti bendrą mokymo(si) objektų ontologiją: suformuotos ir išskirtos šešios pagrindinės mokymo(si) objektų klasės.

5. Remiantis turinio MO, metodinių išteklių ir mokymo(si) metodų objektus aprašančių metaduomenų elementų lyginamąja analize, taip pat MO metaduomenų standartų taikymo modelių sudarymo mokslo bei praktinius principais, LRE LOM AP v.3 modelio pagrindu pasiūlytas išplėstas skaitmeninių mokymo(si) išteklių metaduomenų modelis, kuris leido: (1) struktūriškai aprašyti turinio objektus, metodinius išteklius ir metodinių metodų objektus; (2) automatiškai realizuoti atgalinį MO ryšį, leidžiantis pateikti sąsajas su kitais MO pagal tematiką.

6. Pasiūlytas išplėstas modelis skiriasi nuo LRE LOM AP v.3 modelio tuo, kad (1) patobulintos ir išplėstos trijų valdomųjų žodynų reikšmės, (2) sukonstruoti du nauji valdomieji žodynai.

7. Remiantis LOM standartu ir identifikuotais pamokos plano komponentais, pasiūlytas technologijomis grindžiamas pamokos plano šablonas, leidžiantis automatiškai užpildyti didesnę dalį LOM elementų.

8. Atlikus pasiūlyto MO metaduomenų modelio ekspertinį vertinimą nustatyta, kad pasiūlytas metaduomenų modelis leidžia apytikriai du kartus sparčiau ir tiksliau atlikti MO paiešką, t. y. padidėjo metodinių išteklių ir mokymo(si) metodų objektų pasiekiamumas ir panaudojimas.

9. Pasiūlytas išplėstas skaitmeninių mokymo(si) išteklių metaduomenų modelis yra reikšmingas ir teoriniu informatikos inžinerijos mokslo aspektu (leidžia teikti struktūrinius metaduomenis naujai išskirtiems dviem mokymo(si) išteklių tipams), ir praktiniu taikomumu (padidina mokymo(si) išteklių paieškos efektyvumą ir tikslumą, sudarant palankesnes sąlygas pedagogų kompetencijoms kelti).