A didactic model, definition of learning objects and selection of metadata for an online curriculum

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Key words: *Tele-learning, Educational Metadata, LOM Subset, Learning objects*

Abstract:

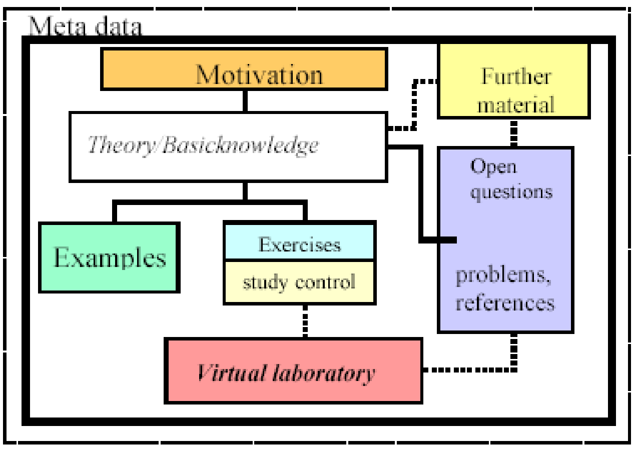
Composing a complex didactic model for technological infrastructure in online courses of studies still poses great problems for computer scientists as well as pedagogues. In the following paper, we are going to present a special didactic model designed for an MBA course, with a high degree of online course offers. Furthermore, we are going to describe its mapping with a subset of the metadata standard LOM and to define concepts and characteristics for teaching material based on different granularity.

1 Project "New Economy": didactical model

This document is based on the project: „development of an online curriculum for the MBA course New Economy", financed by the Federal Ministry of Education and Research (bmb+f). After the completion of the curriculum, teaching modules containing theory, exercises, simulation and games are going to be developed. A didactic model was processed within the project. This model gives the user the opportunity to clearly define the structure of the teaching modules as well as the function of individual components and the possibility of accessing the content.

1.1 Structure of a teaching module

A Teaching module consists of several components which all have a defined status within the module. See beside.



Motivation

The motivation is aligned with the learning targets that the learner should attain by using this teaching module. Motivation can be based on visualisation (graphics, animation, video), examples or a presentation of learning content. It is supposed to motivate the learner to work on and with the teaching module. Motivation may be closely connected to theory and basic knowledge.

Theory/Basic knowledge
The component theory/basic knowledge presents concisely the content of a teaching module within a chain of main facts. The learner has access to further parts of the content and comments via links. Additionally, references to exercises, examples, questions or problem oriented cases are possible where didactically appropriate. Therefore, the component theory/basic knowledge contains two parts: „chain of main facts" (access via motivation) and further content.

Examples
Examples are used to comment the content within the component theory/basic knowledge. They can explain a concept, a procedure (e.g. within a company) or a theoretical problem. In order to visualise complex procedures of theoretical problems, examples can also be underlined by animations.

Exercises/study control
Exercises promote an independent confrontation of the learner with the acquired content. Exercises are placed didactically reasonable within the component theory/basic knowledge, basically at the end of a teaching part. An individual learner, a group or a tutorial can work on these exercises.

Open questions, problems, references
The learner has to deal autonomously with questions and problems which are part of the teaching module but exceed its content. The lessons learned can be transferred to other fields. Presumptions and statements are challenged within the teaching module.

Further material
Literature and other material can be indicated in the list of references as well as placed online (.html of .pdf data).

Virtual laboratory
Simulation software is supposed to be supplied in the virtual laboratory for interactive application of the content.

1.2 Options of access to the content

There are four access options, which can be activated alternatively – even if one special option was already chosen.

Possible access: instructed access – learning episode
Via instructed access, the learner has several learning episodes, which he can follow. The combination of these learning episodes depends on the target group and is defined by the professorship. The professorship can combine individual teaching modules, form a learning episode and lead the learner through a defined series of learning episodes. The creation of such a learning episode depends on the target group and degree of difficulty: the professorship itself defines the sequence of teaching modules. Each learner is part of a special user group. For creating these groups, traditional scenarios (exercise groups, tutorial) advanced training scenarios (classes, qualification courses, companies) as well as online specific scenarios (CSCW, self study in voluntary learning groups) are supported. The classification of a group is based on user hierarchy at registration. The learners of a group only see the learning

episode defined for their purposes. This learning episode contains the specific navigation within the learning environment. In case the learner wishes for other learning episodes or ways of access to be displayed - these can be activated.

Possible access: problem oriented access
The learner can here choose a case study to work on. A case study contains complex facts that are edited for multimedia viewing. The case study generates exercises for the learners, which – if possible – have to be solved in groups. In order to solve the indicated questions, the learner makes use of teaching modules assigned to case study. These teaching modules can be activated and used within the case study navigation, but are not placed in the foreground. Content describing metadata is necessary for finding appropriate material in order to solve a problem.

Possible access: selection via structure plan (sitemap, mind map)
The standard teaching episode corresponds to the curriculum structure (downwards) developed by the project partners.
Via the structure plan, the learner has access to individual teaching modules of the curriculum. This type of accessing the module resembles accessing learning material via text-books. The learner can move through the material supported by the hierarchic structure of the curriculum (standard learning episode). He can also call individual chapters of the curriculum and work on single subjects.

Access option: selection via search/index
The option "search" enables the learner to specifically search one or more teaching modules and then work on these modules. The searching function accesses mainly content describing and classifying metadata.

2 Characteristics for learning objects of different granularities

One of the central characteristics within the project is the so-called learning object. We use this characteristic as "*Any digital resource that can be reused to support learning"* [1], [2], [3] and [4]. In the parlance of the project „New Economy", different characteristics are used for different types of learning objects. These learning objects have different qualities on different scales. For example**:**

- **Fundamental information object** – very small learning object, without complex logical structure, which sums up physical media (picture, video, text) to a didactically appropriate unit.
  Related characteristics and definition: data element, assignable unit [5], fundamental, combined-closed learning object [3], learning fragment [6]„*Information object*" [1]

- **Learning component** – small learning object, combining a small number of information objects such as headlines, texts, pictures, enumerations, definitions and references to other modules in order to form one of the following features: motivation, theory, example, exercise, links and continuative subjects, open questions, problems, laboratory. It contains a logical structure for mediation of content based on a precise didactic model or similar content modules. Has a high degree of reusability, especially in creating new teaching modules and learning units.
  Related characteristics and definition: course element, assignable unit [5], generative-presentation learning object [3], reusable information object (RIO) [7]

- **Learning module** – combines learning components (at least motivation, theory and example) and information objects in order to mediate a specific subject. A teaching module represents a logical structure with a didactic aim consisting of individual learning components.
  Related characteristics an definition: reusable learning object (RLO) [7]

- **Learning unit** – structure designed do mediate a complex context, maybe even overall subjects. It combines teaching modules and learning components, e.g. a case study with three teaching modules combined with the learning component "laboratory". It has no content of its own. A learning unit connects teaching modules, which leads to a structure with greater independence.
  Related characteristics and definition: lesson, block [5], Generative-instructional learning object [3]

- **Course** – finished course used to mediate complex content, competence and knowledge in one concrete field to one ore more students. It combines learning units, teaching modules and can be part of the curriculum. Furthermore, the course has a highly logical structure and can be re-used outside the original context.
  Related characteristics and definition: course [5]

- **Curriculum** - arrangement and composition of courses and learning units according to one ore more academic specifications.
  Related characteristics and definition: Curriculum [5]

- **Learning episode** – structure (according to target group and/or learner) consisting of modules and learning units of a course or curriculum. The learning episode can individually be adjusted to the learner. The number of knots and linked components depends on the previous knowledge of the learner. Learning episodes permit an individual adoption of the organised learning procedure.
  Related characteristics and definition: structure element [5]

- **Sequence** – result of individual research within different repositories, in order to extend personal knowledge. It is part of the informal not organised learning procedure.
  Example: an external learner chooses the subject „Blueprinting"
  Related characteristics and definition: structure element [5]

For this project, we developed a taxonomy for these characteristics [8]. In this taxonomy, the above-mentioned eight types are distinguished. Some of these types can be arranged to form a larger unit and can be interlaced. They form new types of undefined number and size. Groups of object groups form a specific hierarchy.

3 Metadata for Learning Objects

Metadata for learning systems are pieces of information that describe a learning object. They facilitate an automatic and dynamic combination/compilation of personalized instruction units for the individual learner via instructors as well as autonomous, intelligent learner-operated computer programs [9].

[10] lists the following basic reasons for an implementation of metadata within the learning system:

- **Sufficiency of description**

Does the learning object offer a sufficiently exact description of its contents with regard to the amount, quality, target group, timeliness etc. by the contents alone?

- **Scalability**
  Regarding a great number of users, a full-text analysis is not always the most efficient tool for large-size repositories. Metadata facilitate highly aligned and rapid queries at the expense of flexibility.
- **Interoperability**
  If different systems can be settled on a common metadata scheme each system will be able to search within the metadata of the others.
- **Dissociation of metadata and contents**
  Dissociating metadata and contents, the object-attributing metadata can become ubiquitous. The actual learning objects will be released only after payment. If, in addition to that, the learning objects are stored/ saved redundantly the learner may inquire metadata of the requested learning object centrally. This then gives him the opportunity to withdraw the requested learning object from a repository close at hand, for example [11][15].

3.1 Relations between learning objects in LOM

Metadata describe content and structural features and components of learning objects. This allows a classification and linking with other learning objects as well as an arrangement of the learning object within the learner's learning field. A combination of categories and data elements is called a scheme. A Metadata scheme consists of the amount of descriptive attributes and their domains (areas of definition). Presently, there are different standards for learning technologies. Among the most important are LOM, IMS and the CanCore, SCORM, AICC and LRN. For this project the LOM standard, being the basis for many other standards, was chosen. The LOM standard assesses a so-called basis-scheme that permits a description of all features (80) of learning objects. The relations between learning objects can be sub-divided into 3 categories:

- **structural relations**, that reflect the original document structure during a modularization of documents**,**

- **relations of content**, that can be deduced from semantic interdependencies between learning objects**,**

- **ordinal relations**, that result from a scaling/grading of learning objects (f.e. on a time-scale)[1]

Structural Relationships in LOM

Relations that can be formulated with objects of the category *LOM relation* of the LOM set of data are used to link single learning objects to a more comprehensive learning object. This takes place in the shape of a course, a learning unit or a module.
This approach works especially well with modularised textbooks, lecture scripts and slides. This material comes structured in chapters and sub-chapters per se. A ready-made structure likes this should be project able in a metadata scheme of the project.
This approach offers the following advantages:

[1] at the present state of the project still neglected

- ready-made structural information can be projected in LOM and stand by for information retrieval services
- compound/ complex learning objects are implicitly projected
- granular learning objects are easily aggregated to new learning objects

Content-relations in LOM

Contents-relations between learning objects have to be analysed if learning objects are to be combined according to the requirements and knowledge of learners. These relations can be sub-divided into semantic, rhetorical and pragmatic links [13]:

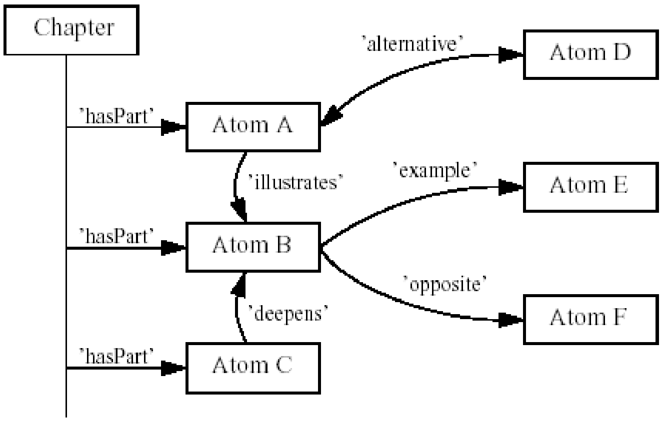
- **Semantic links** relate words and items with similar, opposite or „is a“ resp. „is part of“ meanings. Semantic links occur mainly on a media-object level; less commonly also on page or chapter level**.**

- **Rhetorical links** serve the role to lead the learner to a certain learning achievement in a succession of pieces of information. Rhetorical links thus are most of all a tool of the author with the help of which definitions, explanations, illustrations, excurses and similar devices can be integrated into a hypertext**.**

- **Pragmatic links** are, in opposition to rhetorical links, no relations between media-objects, but rather relations between a subject and its learning assignment resp. the actual learning situation of the learner. Examples for pragmatic links are warnings, hints to user-related examples and manuals.

In [12] contents-relations between learning objects were defined by rhetoric-didactic relations. These are:

- Example: learning object E contains an example for learning object B
- Illustration: learning object A contains an illustration for learning object B
- Entity: learning object B is in content a subordinate of learning object A
- Restriction: learning object B limits the contents of learning object A
- Extension: learning object B contains additional information with regard to the contents of learning object A
- Intensification: learning object C intensifies the contents of learning object B
- Opposite: the contents of learning objects B and F are opposites
- Alternative: learning objects A and D are identical in content but differ in form or coding.



rhetoric-didactic relations between media content elements, source [12]

Most of these relations can be calculated with the help of concept hierarchies and relations between concepts and learning objects, i.e. they do not have to be listed explicitly. Algorithms considering previous knowledge, learning assessments and document structures have been introduced in [13].
The category *LOM.Relation* thus plays an important role in the coding of *structural* and *content* relations between the respective learning objects within the LOM basis scheme. The category facilitates a phrasing of directed relations (starting from the LOM set of data where they are phrased) to a target LOM set of data. In the data field *LOM.Relation.Kind* the type of a relation is stored. The following types are stored in the LOM-draft:
'IsPartOf', 'HasPart', 'IsVersionOf', 'HasVersion', 'IsFormatOf', 'HasFormat', 'References', 'IsReferencedBy', 'IsBasedOn', 'IsBasisFor', 'Requires', 'IsRequiredBy.
These relation types are based on the Dublin Core [WKL98] and occur in pairs to ensure that via two opposite unidirectional relations one bi-directional relation between 2 LOM sets of data can be created. In *LOM.Relation.Resource.Identifier*, the identifier of the LOM set of data of the target relation is stored. The content of this field consists of identifiers of all LOM sets of data. (see [12])
LOM.Educational.Learning.Resource.Type offers an allocation of single components (example, motivation, theory, summary etc.) to a module. This facilitates a representation of the project-relevant parts of the didactic model.

3.2 Using LOM meta data in the project „New Economy"

The meta data subset was developed by using principles of reusability, standardization and technical realization. Main objectives were:

- Reliability of attributes defined in LOM Version 6.5 [5]
- Accordance to vocabulary and principles of the CanCore report [14]
- Consistency of metadata elements within all repositories of the project partner
- Limitation of the number of obligatory properties
- Using existing techniques for automated annotation of structure-related properties

The following tables show properties of the LOM basis scheme. We categorized them in four groups:

1. Obligatory metadata properties, which must be annotated by the author when creating a new learning object (11 entries).

2. Automatically added properties using templates, technical information extracted from Mime Type and size information of the document, structure related information, extracted by using software for extracting structure relations from existing documents and redundant copies from other metadata elements. (20 entries)

3. Optional properties, added by authors on demand. (23 entries)

4. Unused metadata elements. These metadata elements can be added if needed, but will not be supported when querying a repository. (13 entries)

With this approach, each learning object is described by using at least 31 and can be described with a maximum of 54 properties. Properties added with a"*"contain no data since they represent the top level of a complex property. Columns one to seven will be published outside the repositories. These properties will sometimes be copied by using columns eight and nine that are repository specific (see also [5]). Some properties are represented in more than one category (e.g. element 7.1). This happens, when data can either be automatically extracted or has been annotated manually.

Obligatory properties, edited manually by content authors

(1) General	(2) Life Cycle	(3) Meta-Metadata	(4) Technical	(5) Educational	(6) Rights	(7) Relation	(8) Annotation	(9) Classification
(1.2) title	*(2.2) status*			(5.2) learning resource type				**(9.2.) taxon path*
	(2.3.1) role			(5.8) difficulty				(9.2.2.2.) entry
	(2.3.2) entity			(5.9) typical learning time				(9.3) description
								(9.4) keywords

Automatically added properties , based on existing templates or document structures

(1) General	(2) Life Cycle	*(3) Meta-Metadata*	(4) Technical	(5) Educational	(6) Rights	(7) Relation	(8) Annotation	(9) Classification
(1.1) identifier	*(2.1) version*	*(3.2.1) catalogue*	(4.1) format			*7.1. kind*		(9.2.2.1) Id
**(1.3) catalogue*	*(2.3) contribute	*(3.2.2) entry*	(4.2) size			*(7.2.1) identifier*		(9.2.1) source
(1.3.1) catalogue	*(2.3.3) date*	*(3.2) catalogue entry	(4.3) location					
(1.3.2) catalogue entry								
(1.4) language								
(1.5) description								
(1.6) keywords								

Optional properties, will be added on demand by content authors

(1) General	(2) Life Cycle	(3) Meta-Metadata	(4) Technical	(5) Educational	(6) Rights	(7) Relation	(8) Annotation	(9) Classification
		*(3.3) contribute	**(4.4) requirements*	(5.1) interactivity type	(6.1) cost	(7.1) kind	(8.1) person	*(9.1) purpose*
		(3.3.1) role	(4.4.1) type	(5.3) interactivity level	(6.2) copyright and other restrictions	(7.2.1) identifier	(8.2) date	
		(3.3.2) entity	(4.4.2) name	(5.5) intended end-user role	(6.3) description		(8.3) description	
		(3.3.3) Date	*(4.6) other platform requirements*	(5.6) Context				

		(3.4) metadata scheme						
		(3.5.) language						

Unused properties

(1) General	(2) Life Cycle	(3) Meta-Metadata	(4) Technical	(5) Educational	(6) Rights	(7) Relation	(8) Annotation	(9) Classification
(1.7.) coverage		(3.1) identifier	(4.4.3) minimum version	(5.4) semantic density		*(7.2) resource		
(1.8) structure			(4.4.4) maximum version	(5.7) typical age range		(7.2.2) description		
(1.9) aggregation level			(4.5) installation remarks			(7.2.3) catalogue entry		
			(4.7) duration					

Apart from this selection, there are best practice recommendations for authors, descriptions of the specific attributions and their application in the project as well as templates containing standard data for a blank, new entity of a learning module[8]. This template was intended to facilitate the choice of metadata that will have to be amended and to avoid a multiple calculation of metadata.

4 Conclusion and Outlook

In this paper we presented a particular didactic model designed for an online MBA course of studies, with a high degree of online course offers. This model supports four access options, which can be activated alternatively. We defined a set of terms and characteristics of learning objects for arbitrary granularities of learning related content within the project context. For realising the model specific access options learning objects are annotated with meta data. Corresponding to the model we developed a subset of LOM metadata elements. By using existing techniques for extracting structure information of existing learning related documents and using templates for static meta data values we could automate the metadata annotation.

For the implementation of a hybrid course of studies with a high proportion of online learning material a particular didactic model was designed. This model contains different access options for learners‘ material as well as terms and characteristics of learning objects of different degrees of granularity. Ensuring the access to learning material required by the model these metadata will be annotated. Therefore, a model-specific sub-range of the LOM metadata standard was chosen. Certain pieces of metadata of this sub-range with structural and technical descriptions can be taken automatically or from a common template.
By annotating learning-related documents with LOM metadata, content developers may profit from all advantages when using an established and approved standard. Since LOM focuses only on annotating documents, some specific properties of a didactic model, like learning processes, learning sequences, complex relations between learning materials, group scenarios, can be modelled with LOM only insufficiently. Initiatives that integrate LOM and existing educational modelling languages like EML, Palo or LMML could provide content developers, education specialists and computer scientists with a potent and unique modelling language for modelling and developing complex, powerful educational infrastructures.

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