Contextualization of Learning Objects for Self-Paced Learning Environments

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***Abstract*— The use of learning objects in constructivist learning environments causes a dilemma between reusability and context representation. The extension of current metadata standards with XML-based context resources offers a broad, transparent and efficient representation of the context of learning objects. They are the basis for context aware knowledge acquisition in self-paced learning environments.**

E-learning; hypermedia; learning context; context model; XML; LOM

I. INTRODUCTION

In contrast to traditional face-to-face learning, e-learning applications are available independent of time and space. They have in particular the potential to support self-paced and problem-oriented learning from a constructivist point of view. Learning processes are performed individually through active construction based on existing mental representations. Those individual learning processes can hardly be supported in face-to-face arrangements with a multitude of participants.

In addition to self-paced learning, constructivist learning environments are mainly characterized through representation of multiple contexts and perspectives [14] Transparent context representation of learning content is crucial for flexible knowledge acquisition and to apply the knowledge later on. Hypermedia learning environments meet these requirements. Furthermore, they also support various information processing abilities of learners through multifaceted encoding of learning contents [14, 15]. Due to variation and choice, they also motivate the learner during his learning process [8].

However, while using hyper-structured learning contents the modularization of existing learning resources is necessary. Thereby learning material is divided into small self-contained units. The main reason for using learning objects during the modularization process is the reusability of learning content for several learning scenarios and the effective development of digital learning material accordingly. Learning objects are described as "any digital resource that can be reused to support learning" [16]. These building blocks for learning mainly represent de-contextualized knowledge. The less specific context a learning object contains, the sooner it can be used for different learning scenarios and the higher is its "reusability" value. This modularization is often associated with disorientation and cognitive overload problems on the learners' side [3]. Only a transparent context representation of learning content allows active construction of knowledge and guarantees learning success [6]. This dilemma is also called Reusable Object and Instruction Paradox [1].

This paper points out how contextualization of learning objects independent of their granularity can be realized for hypermedia environments that support self-paced learning. First, the context that is relevant for self-paced learning environments is characterized. In addition, the deficiencies of existing metadata standards for a comprehensive, transparent and efficient description of the context of learning objects are illustrated. Subsequently, the approach and the solution of XML-based context specifications, which are used to describe the context of learning objects, are presented.

II. CONTEXTUALIZATION OF LEARNING OBJECTS

A. Access to Learning Objects in Hypermedia Learning Environments

In order to define the relevant context of learning objects it is crucial to know how learners access learning material in self-paced learning environments. The access to learning contents in hypermedia learning environments mainly happens topic-oriented. Based on desired knowledge the learner selects relevant nodes from a network. It is necessary to illustrate the relationships between learning contents of the current node and other contents as well as previous knowledge. On the one hand this is essential for learners in order to integrate the semantically impact of the information into the own knowledge structure and existing mental representations [12]. On the other hand, it must be transparent for the learner, which learning paths he can

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choose according to his desired and previous knowledge. For the representation of the context generic terms, specific terms and synonyms of the current topic as well as additional qualified relationships are being used (see fig. 1). Appropriate elements for navigation allow the retrieval of several contents and mapping techniques support the transparent presentation of the context [13].

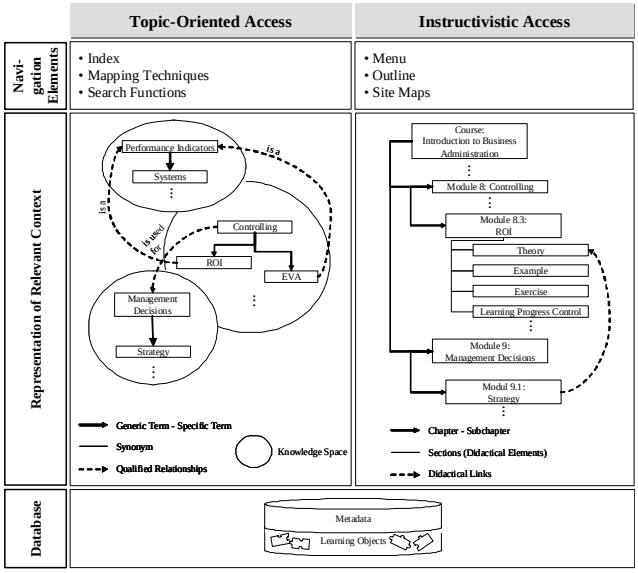

Figure 1. Access to Learning Objects

It is also necessary to organize learning material hierarchically, i. e. to provide content refining paths. The learner can determine his current learning status and is guided through individually selected contents by an instructivistic approach. Here the learning context is classified into several chapters which can be divided into subchapters and sections [2]. A standard learning path which reflects the curriculum structure appears for the learner. Besides this hierarchy of chapters and sections there are often didactical links [2]. Those cross-references occur i. e. for a comparison. The learner navigates through the contextualized content by menus, outlines, and site maps.

B. Metadata

The context of learning objects is described by metadata, which on the one hand characterize the learning objects themselves and on the other hand the relationship between each other [10]. Describing learning objects with metadata is a part of learning technology standards, which were developed due to compatibility and reusability of learning resources. Standards, which provide elements for describing relationships between learning objects, are of special interest to contextualization. This is widely realized in the IEEE LTSC Learning Object Metadata (LOM)-Standard [9]. The category “LOM.Relation” plays an important role in specifying the context. This category allows the definition of directed relationships, starting from the metadataset in which they are formulated to various target metadatasets [7].

However, while using the metadata scheme for a detailed description of the context three fundamental problems appear. In order to realize a bi-directional connection between learning objects always two opposing uni-directional relations have to be defined. Those pair wise connections demand a high effort when first specifying the context, as all relevant learning objects have to be found first which are to be referred to. In case of extension and updating as well as removal and exchange of learning contents metadata of both learning objects have to be changed.

As the authors of the learning objects mainly carry out the creation of metadata sets, domain experts have to define a framework for the relevant context. This aspect is not part of current metadata schemes.

An additional problem results from the limited language space of the LOM scheme relationships, which do not admit a comprehensive description of the context [1].

The solution proposed here is to separate context information from learning objects and metadata. The metadata of the learning objects remain untouched so that context information can be extended and completed as well as maintained by an individual domain expert. This assures consistence and timeliness and reduces the complexity of defining metadata. The relevant context information is represented as a classification scheme.

C. Subject-Based Classification

Subject-based classification classifies objects by relevant topics 85]. As a basis the ISO standard for topic maps allows the configuration of semantic networks which are separated from the referenced objects [11]. Therefore, the three constructs topics, associations and occurrences are available in topic maps.

All subjects but also abstract concepts and categories can be defined as topics [4]. Associations link topics to each other and also relationship types can be mapped. Relationships do not exist generically but are described in detail. A network develops from a hypergraph in which the topics are linked by associations, which may have several topics at their ends [4]. Finally, learning material which cover the topics or which are relevant for them is linked via occurrences to the topics.

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Thus, topic maps have the advantage to build up a flexible model for mapping the context to an open vocabulary [5].

D. Structure-Based Classification

Structure-based classification groups modular objects around a given didactical structure of a course or learning material. In order to represent the curriculum structure in a didactical way hierarchically organized classification systems have to be established. Taxonomies that already exist within the LOM standard provide an appropriate basis. However, they have to be extended by the possibility of building sequences of learning objects. Interlocking chapters and subchapters represent the basic structure. For further description, they are enhanced with a numbering system, which specifies the position in the whole course. In case of a didactical and organizational motivated conversion of the course structure, learning objects do not have to be described again, as changes are made separately in the classification system.

Furthermore, chapters and subchapters have a rhetorical-didactical internal structure, which is characterized by the learning elements such as theory, exercises, and learning progress controls (see fig. 1). For the representation of this internal structure, labeling of the learning objects' types is sufficient as the sequence of the learning elements is determined independently by the learner within a self-paced learning environment.

III. XML-BASED CONTEXT SPECIFICATIONS

A. XML-ThemeMap

The ThemeMap is alligned to the ISO standards for topic maps. The main difference is that the construct occurrences is not used because authors only specify a uni-directional link from the learning object metadata to the topics due to the problems mentioned in section 2.2. Figure 2 shows the elements of the ThemeMap.

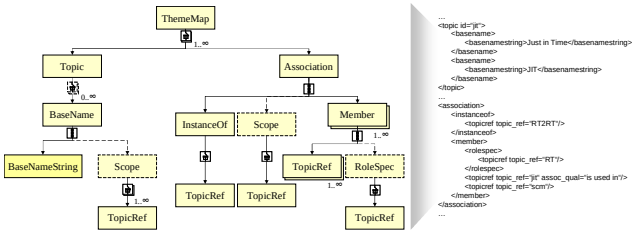

Figure 2. XML Structure of ThemeMap

Topics comprise subjects the learning material is addressing to. One or several *BaseNames* can be assigned to a *Topic*. Also synonyms can be given. Furthermore, the element *Scope* also allows the indication of a domain with a valid *BaseName*. Each *Topic* has an identification number (ID) which is referred to within the learning object metadata in order to classify the context.

In order to create relationships between topics with the element *Association* a reference type has to be chosen. All intended relationship types are defined as a *Topic*. The element *InstanceOf* refers to one of the defined relationship types. The element *Member* comprises *Topics* that will be associated by relationships. By using the attribute "*assoc_qual*" of *TopicRef* a qualified description of the relationships is possible.

B. XML-ChapterMap

Figure 3 shows the elements provided for the specification of didactical structures.

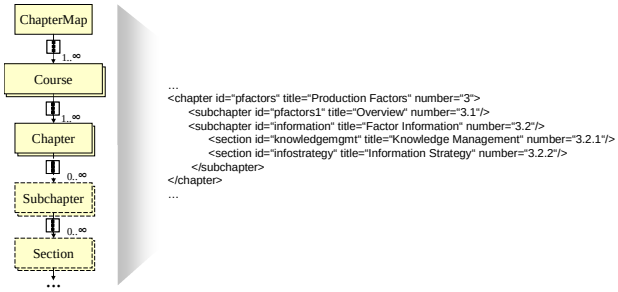

Figure 3. XML Structure of ChapterMap

All elements possess an attribute for identification within the XML data. Metadata do not have to be adapted in case of changes of the course structure because the learning object metadata is linked with the ID of the element. For rhetorical-didactical cross-references the metadata of the learning object refers to a further element-ID and allocates the attribute "*mentioned*".

IV. CONCLUSIONS

The presented contextalization of learning objects has been realized within the course "Introduction to Business Administration" of the "Bavarian Virtual University". The context is separated from the learning objects and included in context resources that permit easy mapping and updating by a domain expert. The realized self-paced and hypermedia learning environment converts the XML-based context resources and generates dynamically the user interfaces for a topic-oriented as well as an instructivistic access to the learning material.

The contextualization of learning objects using ThemeMap and ChapterMap proposes an appropriate

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extension for current learning technology standards. ThemeMap is a flexible instrument for context mapping which may be customized to the individual e-learning content and may be processed automatically. In a wide sense contextualization not only covers the representation of relationships between learning objects but also takes into account learning environments in real life scenarios, e. g. at work or at home, and supports social context, e. g. learning groups or communities. These are open fields for research in many ways. ThemeMap can also be used to describe such context elements.

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