Phoenix Tool: A Support to Semantic Learning Model

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Abstract

Share and reuse of learning objects are an important issue, that are not solved by simply adding a metadata description. Their contextualisation as well as their level of granularity still pose some difficult and unsolved questions. We will present in this paper a Semantic Learning Model (SLM) facilitating the reusability of learning objects according to a pedagogical context. Our main contribution lies in the explanation of the decomposition process of pedagogical entities using an authoring tool called PHOENIX.

1. Introduction

A number of commercial products such as Blackboard, WebCT, or Lotus Learning Space provide authoring tools based on the ADL Sharable Content Object Reference Model (SCORM). This model is based on the assumption that the user - be it a learner or an author - interacts only with the Sharable Content Object (SCO) layer, excluding any direct access to other sources of pedagogical content. Furthermore, the design of components cannot make use of pedagogical approaches such as constructive or collaborative learning.
Conversely, many non-SCORM systems - such as ActiveMath [12], MetaLinks [14], NetCoach [19], DCG [17], Interbook [3] etc. - offer a choice of pedagogical approaches but have a number of severe drawbacks such as their lack of interoperability or flexibility, not to mention the fact that they are self-contained and therefore are unable to connect to external services nor facilitate reuse or collaboration.
Therefore, we sense a real need for an authoring tool that would combine the positive aspects of both worlds avoiding at the same time their inconveniences.

In the context of ARIADNE [1], we develop an authoring tool that generates educational indexed documents and loads them into the Knowledge Pool System (KPS), a learning objects repository (LOR) [5].

We focus on the problem of multi-source document creation [11] and offer the possibility to both edit new material and/or include existing items reusing them as such or modifying them on-the-fly. Many issues are thus raised such as: at what level of granularity should learning items be segmented into to facilitate reuse? How can search and access to learning items be improved? Is the learning object meta-data standard (LOM) sufficient for indexing and querying?

We will try and show how some of these interrogations could find a solution in a new learning objects content model called the Semantic Learning Model (SLM). The discussion of learning object characteristics such as sequence, scope and structure led us to propose a classification of different types of learning objects. We then apply some metadata standards to our SLM and perform our taxonomy in the KPS by the way of decomposition process.

2. Semantic Learning Model

Some systems such as Learnativity [18], Scorm [4], CISCO [2], NetG [11], IMS/LD [9] and General Model [6] dealt with constructing a classification for learning items in order to facilitate learning resources reuse.
On one hand, it seems obvious that the smallest the level of granularity of a resource is, the most reusable it is but the less contextualized it is.
On the other hand, resource's granularity depends deeply on users needs because authors could have to reuse an atomic information as well as a whole course.
That's why, we need to associate to learning objects different levels of granularity so that users can access it fitting their needs.

2.1 Description

In order to deal with multiple source document we have further refined our approach (fig 1) and devised a new model baptized the Semantic Learning Model (SLM) [8].

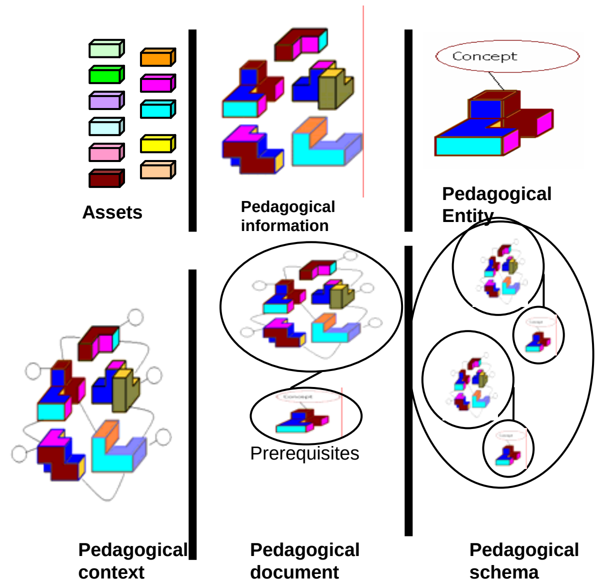

Figure 1. *Learning object taxonomy*

We divide the SLM into 6 categories:

1. *Assets:* The lower level of granularity of a document is an Asset. Assets can be pictures, illustrations, diagrams, audio and video files, animations, and also text fragments.
2. *Pedagogical information*: Pedagogical information is a group of assets expressing the same meaning. For example, a figure associated with its comment is a pedagogical entity.
3. *Pedagogical entities*: It's an information entity associated with a pedagogical role. Four roles are specified: concept, argument, solved problem and simple text but for the model to be adaptable, the role can be anything else as long as it is previously defined by the pedagogue.
4. *Pedagogical context*: the pedagogical document includes the pedagogical context associated with prerequisites which consist of a set of external pedagogical entities acting as “concept”. In fact, prerequisites are either a part of the associated pedagogical context or an external concept. We make the assumption that prerequisites added to the pedagogical context to form a pedagogical document are external concepts.
5. *Pedagogical document*: the pedagogical document includes the pedagogical context associated with prerequisites.
6. *Pedagogical schema*: Many pedagogical documents are grouped in order to make a curriculum. This group is called pedagogical schema.

From the lowest level (assets) to the highest (pedagogical schema), semantic informations such as role, context, relations between pedagogical entities or pedagogical documents, prerequisites, are enriched associated learning objects. That's why we baptize our model "Semantic Learning Model".

2.2 Mapping between different models

Tabel 1 compares the different e-learning Content Models including with our SLM:

- CISCO identifies RIOs, assessments, overviews and summaries, which can be mapped onto pedagogical information. An RLO is an aggregation of these components and can be assimilated to the pedagogical context. RLO/RIO model defines the components of a learning object more strictly: the model specifies that a learning object (RLO) contains 7 ± 2 RIOs, whereas the presented model does not restrict the number of components of a learning object.
- Within the SCORM aggregation model, an asset can be associated to an asset. SCOs can be associated with pedagogical information and content aggregations can be mapped onto pedagogical context.
- The learnativity model maps easily onto the represented model. Raw media elements are associated with assets. Information objects like processes and procedures are abstract types like pedagogical information. Learning objects and aggregations fits within the represented model. The three aggregation levels of the learnativity model (learning objects, aggregate assemblies and collections) are included in our model.
- NETg uses the term learning object which comprises a learning objective, a unit of instruction that teaches the objective, and a unit of assessment that measures the objective. These are abstract types, which can be assimilated to a pedagogical information. NETg defines aggregations that fits the constraints of our model.
- The General Model uses content fragments which can be mapped onto assets. Content objects can be associated to pedagogical information. The Learning Object can be considered as an aggregate including the pedagogical entity, pedagogical context and pedagogical document.
- IMS/LD utilizes the learning object as any other resource whatever its level of granulartiy. So, a learning object represents the lowest level of granularity which corresponds to assets in the SLM model. An environment is composed of different resources and can thus be mapped onto pedagogical information. A role matches nicely a pedagogical entity because of the added value it contains compared to the level below.

General Model [6]	Content fragments	Content Objects	Learning object			
Learnativity [18]	Raw Media	Information Object	Learning Object	Aggregate Assemblies	Collections	
SCORM [4]	Assets	SCO Content	Aggregation			
CISCO [2]	Content Items	RIO	RLO			
IMS/LD [9]	Learning objects	Environments	Role parts	Acts	Plays	Units
		IMS Simple Sequencing	Support/Learning Activities	IMS Simple Sequencing		
Netg [11]	Raw contents	Objective activity Assessment	Topic	Lesson	Unit	Course
SL Model	Assets	Pedagogical Information	Pedagogical Entity	Pedagogical context	Pedagogical document	

Table1. *Mapping between different Metadata Models*

An activity can be mapped onto a pedagogical context due to the fact that at this level the different pedagogical entities aiming at the same target are aggregated Eventually, a unit is mapped to pedagogical document.

SLM model is a way to improve learning objects reusability. To reuse a pedagogical item, we need to search by submitting queries, find and retrieve it.
A way to facilitate this task is associating pedagogical items through different levels of granularity to a metadata.

3 Metadata

Metadata is textual information that is formatted according to rules defined in XML [23] or eXtensible Markup Language. XML and metadata are extremely useful to describe digital media and especially 'rich media': video, audio, and streaming media.
Metadata is recognized to be a key element for discovery, interoperability, accessibility and reuse of digital educational content. It standardizes the descriptive language of digital content, provides consistent, searchable keywords through ontologies and controlled vocabularies in Meta tag elements and modifiers. It offers methods for usage and access control through digital rights management systems.
The development of metadata standards in response to the need to deliver digital educational material is a relatively new endeavour, driven by the network based initiatives to deliver on-line material. Learning metadata standards pose different levels of representation granularity [15], as shown in Figure 2.

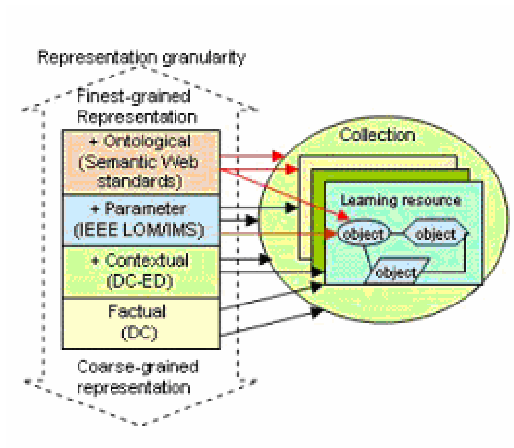

Figure 2. *Representation framework*

3.1 Ariadne Metadata

The ARIADNE Knowledge Pool System is a distributed repository for learning objects [5]. It encourages the share and reuse of such objects. An indexation and query tool uses a set of metadata elements to describe and enable search functionality on learning objects. To ensure simplicity, understanding and adaptability for the ARIADNE community, data elements are grouped into six categories:

1. General: groups the general information that describes the learning object such as document title, document language, etc.

2. Semantics: groups elements that describe the semantic classification of the learning object like the science type, main discipline, sub discipline etc.
3. Pedagogical: groups elements that describe the pedagogic and educational characteristics of the learning object such as semantic density, interactivity level, etc.
4. Technical: groups elements that describe the technical requirements and characteristics of the learning object like OS version, required disk space, etc.
5. Indexation: groups elements that describe the general information about the metadata itself of the learning object such as the identifier of the metadata instance, metadata creation date, creator, etc.
6. Annotations: groups elements that describe people or organizations notes about learning objects like annotator, language of annotations, and date of annotation.

These specifications together with similar specifications contributed by IMS [10] served as the starting point for the IEEE LTSC LOM standard [13]. LOM has a wide set of globally agreed metadata elements.
Metadata data elements of LOM are grouped into nine descriptive categories: General, Life cycle, Metametadata, Technical, Educational, Rights, Relation, Annotation, and Classification. These specifications have been defined and agreed on by a global community to enable share and reuse.

3.2 Assets, Information entities, pedagogical entities

Ariadne metadata description for author, publication date, source and topic is sufficient to preserve copyrights and for indexing.

3.3 Pedagogical context

Almost all standards are defined for representing content characteristic-based information. In the case of LOM for instance, metadata information can be 'keywords', 'author', 'version' or even 'size' of the document. Only a few metadata items, such as 'learning resource type', 'intended end user role', 'typical age range' or 'difficulty', are dedicated to educational purposes. These are not yet sufficient to represent different learning context. We need a context sensitive metadata for representing context, objective and semantics of a learning document. So, we propose to add a field called "context" to express this metadata information.

3.4 Pedagogical document

In so far a pedagogical document is concerned, information about prerequisites is needed to choose what document is the most appropriate for the learner. Those prerequisites consist of a set of external pedagogical entities acting as "concept". In fact, prerequisites are either a part of the associated pedagogical context or an external concept. We make the assumption that prerequisites added to the pedagogical context to form a pedagogical document are external concepts.

3.5 Pedagogical schema

A pedagogical schema encompasses a program of study, a workshop, a course, a module, a lesson. Three attributes could be assigned to the global metadata: topic, creator and description.

In fact, as the schema creator is often not the author of all the documents included in the schema, this must be specified in the metadata. Figure 3 shows different metadata layers.

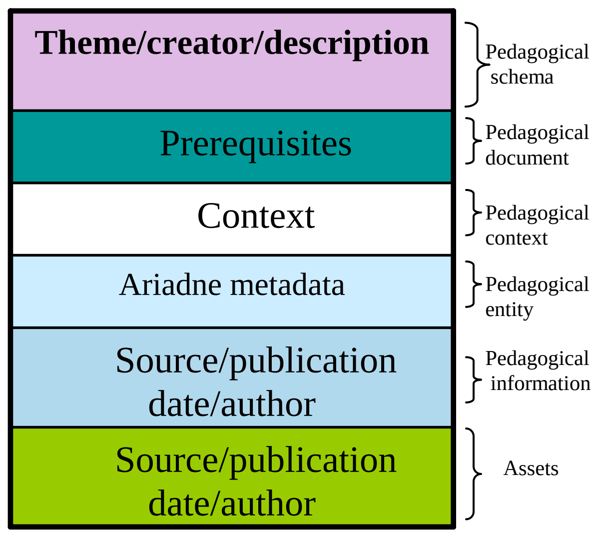

Figure 3. *Metadata taxonomy*

4. Case study

Our case study aims at showing concretely how the SLM can be used with an existing repository of learning objects. I the context of ARIADNE, we chose our Knowledge Pool System (KPS).

4.1 KPS

ARIADNE's concept of computer-based and telematics-supported education relies primarily on an international system of interconnected knowledge pools (the KPS). Prototypes of the tools and basic methodologies for maintaining and exploiting the KPS [6], in all forms of classical, continuing, open and distance education or training have been developed and tested in ARIADNE I and II, stressing the value of share and reuse.

4.2 Phoenix: an authoring tool

Phoenix is an authoring tool allowing users to create pedagogical documents having a specific structure which will be described below and load them into the KPS.

4.2.1 Document structure

A pedagogical document is a compressed file that includes an XML [23] document including images or video clips. The XML document has the following structure (figure 4).

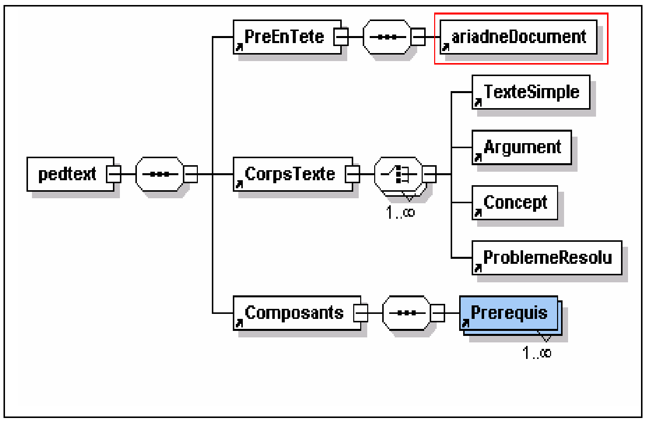

Figure 4. *Pedagogical XML schema*

- PreEntete: The header of the Phoenix document has a LOM compatible format.

- CorpsTexte or presentation chain: In the framework of the segmentation of a single document, we made the assumption that a domain could be represented by a finite number of *presentation chains* each containing at least a concept and its definition [20]. Each concept could be further explained and detailed through a series of pedagogical elements that were graphically regrouped to constitute the above mentioned presentation chain. Segmenting a document consisted precisely in identifying and marking the concepts and their related presentation chains so as to construct meaningful and contextually pertinent pedagogical elements. We could say that the biggest granularity of a document is the document itself while the smallest is any of the identified elements.

The entities it can be composed of are the following:

- *Simple Text*: A TexteSimple is a simple element used to handle unmarked text

-*A Concept* is a semantic element explicitly defined in the text. Its definition is composed of either already identified concepts or of prerequisites. It is characterized by a presentation order, a label, a gender, a type, a complexity degree and content.

- *An argument* is a semantic element that refers to a concept and is used to familiarize, clarify or reinforce the concept. An argument is characterized by its pedagogical function and role, according to an existing typology [21].

- *A solved problem* is a special type of argument that refers to several concepts.

The resulting semantic network highlights the definitional relationships between the concepts and the links between a concept and the pedagogical entities that are related to it in order to reach a pedagogical goal [21].

- Composants: It's composed of prerequisites. A prerequisite is a concept contained in the definition of a concept included in the text, and thus supposed to be already known.

4.2.2 The Phoenix tool

The Phoenix [24] system consists of various toolkits which are responsible for:

1. Conception of Phoenix document model and pedagogical objects,
2. Multiple visualization of the model,
3. Allowing users to edit textual structure in the document using editor options.

4.3 Decomposition Process

The KPS stores pedagogical resources at different levels of granularity. The taxonomy definition will facilitate documents reuse according to users' needs. To perform this taxonomy, a Phoenix document must respect the decomposition process.

The Phoenix tool generates a .phx document which contains an XML pedagogical document. Thanks to the structure previously described, this document can be easily decomposed into two kinds of items:

- The pedagogical context: it defines the information stored between the tags <CorpsTexte> and </CorpsTexte>.
- A set of prerequisites: composed of all pedagogical entities tagged as concept.

The first step consists in separating those items and makes them self-dependents. Each extracted item is replaced by a pointer to it.

According to the semantic network, a pedagogical context is a set of pedagogical entities related to each others. We perform the same process to turn those entities self-dependent.

A pedagogical entity can be separated from its role in order to be reused in another context with a different role. The result of this process is a pedagogical information.
Finally, pedagogical information may be a figure with its description. In order to have the lowest level of granularity, we propose to separate this information and transform it into a set of assets. It is important to notice that unbreakable pedagogical information is transformed to a reference to an asset which contains the whole content.
At the end of this decomposition process (Fig. 5) [8], the new pedagogical document is a set of references to assets organized according to the original structure.

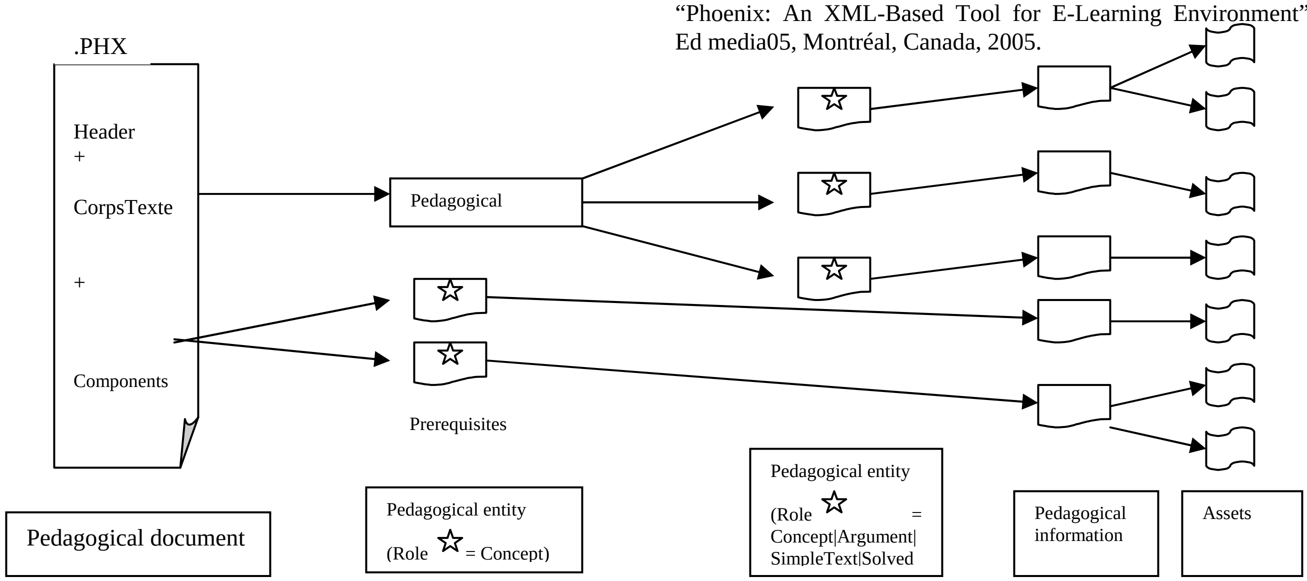

Figure 5. *Decomposition Process*

5. Conclusion

After the exploration of existing learning metadata models and their limitations, we have proposed a taxonomy as a model alleviating and facilitating reusability of learning objects. PHOENIX allows to enrich the Learning Object metadata by including contextual information as well as about its level of granularity. In the future we will concentrate our efforts on finding ways on performing adapted queries so as to be able to retrieve documents according to needs including a specific pedagogical context and a pedagogical scenario.

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