A Data Model for Structuring On-Line Learning Material

Nicoletta Dessì e Barbara Pes
Università di Cagliari, Dipartimento di Matematica e Informatica
Via ospedale 72, 09100 Cagliari (Italy)
e-mail: {dessi, pes}@unica.it

Abstract
In order to structure multimedia learning material a data model is presented that specially addresses scalability and provides an high level of flexibility for interactive distance education environments. The model organizes learning objects in a set of nodes connected to each other through directed edges. Relationships capture didactic aspects and edges allow ordered sequencing of objects. The data organization is searchable, hierarchically structured and navigable according to paths that express the pedagogical strategy of the teacher. Model is mapped in an XML schema that is generic enough to be reused in different contexts and has been usefully applied in a C programming course.

1. Introduction
A learning repository is usually a set of multimedia row materials (text, video, presentation…) structured, collected or clustered by the teacher according to different navigational paths in dependence of learning goals [1,2,3,4]. Particularly, we are interested in recognizing didactic relationships to structure learning material and in modular definition of contents in order to promote the integration of new resources and the reusability of the existing ones in different educational contexts.

2. The data model
Our model supposes the learning content to be composed by learning objects [5] whose organization differs at presentation level (physical organization) as well as at didactic level (logical organization).

By abstracting away some of the detail of both levels, the model consists of two components:
- a set of nodes representing learning objects;
- a set of directed edges for learning object sequencing;
- a set of relationships representing didactic aspects.

We categorize nodes into basic nodes and complex nodes. Basic nodes have no edges emanating from them. They are leaf nodes in the model structure and atomic elements at presentation level. Each basic node has an atomic content expressed by a learning object. On the contrary, the content of a complex node refers to some other nodes through one or more directed edges emanating from it and each going to another node. Each edge links two nodes.

In order to capture didactic aspects of learning objects, the model organizes nodes according to the following relationships:
- Generalizations, linking global didactic concepts to basic nodes (for example, X “is-a” lesson) in a specific didactic context (i.e. lectures, tests, tutorials, etc).
- Associations, representing two peer nodes and meaning that both are at same didactic level (for example, a lesson and the correlate test)
- Aggregations, defining two types of complex nodes: modules and catalogues. A module is a collection of learning objects concerning the same didactic subject. A catalogue is a collection of modules pertaining to the same course.

Edges provide access to complex nodes through the following paths:
- Sequential paths interconnecting a set of modules. Sequencing is planned by the teacher and depends on the pedagogical model adopted.
- Switched paths allowing all modules to be reachable from the catalogue. Sequencing is not mandatory, because edges link the catalogue to a single module.

Figure 1 shows the combination of sequential and switched paths.

![Figure 1. Combination of sequential and switched paths.](image)

3. Mapping to XML Documents
The model mapping is based on XML technology [6]. Basic learning objects are categorized into:
Lessons, containing the explanation of all the concepts inherent in a didactic subject as well as useful advises and explicative examples.

Exercises and the respective solutions, enabling the student practicing.

Tests, conceived to verify the competence acquired by the student. It is a not mandatory self-evaluation tool with automatic feedback.

Each category is defined by a DTD document that allows all learning objects belonging of the same category to share the same structure. This approach facilitates both the modularity and the scalability of the learning environment implementation as well as the reusability of learning objects.

All learning objects concerning the same didactic subject are collected into the same didactic module. In a programming course, for example, we may define the following didactic modules: algorithm, array, linked list, etc. In turn, each module is composed by a set of different atomic components as one lesson, one test, etc.

The structure of didactic module is described by the following DTD document:

```xml
<!ELEMENT MODULE (TITLE, SUBJECT, PREREQUISITES, LEARNING_GOALS, LESSON, EXERCISES, TEST)>
<!ATTLIST MODULE NUMBER CDATA #REQUIRED>
<!ELEMENT SUBJECT (#PCDATA)>
<!ELEMENT PREREQUISITES (#PCDATA)>
<!ELEMENT LEARNING_GOALS (#PCDATA)>
<!ELEMENT LESSON (#PCDATA)>
<!ELEMENT EXERCISES (#PCDATA)>
<!ELEMENT TEST (#PCDATA)>
```

A specific DTD file expresses a catalogue as a collection of didactic modules and also stores some sample metadata referring to general information about the course (for example, the teacher name).

The appearance of the documents on the user’s screen depends on the associated XSL style-sheet, which is responsible for the presentation style (font, color, size...) and for content selection. According to the didactic context and the user needs, presentation is customized by the application of different filters and/or different graphic styles to the same set of data. As a consequence, the learning content is separated not only from its structure, but also from its presentation, allowing a great flexibility in the course delivery.

4. Model validation

Since 1999 the University of Cagliari offers a distance course in Computer Science to students in four sites of Sardinia, whose distance is over 200 Km. At the main site (Cagliari) students attend live lectures. A video-conferencing system enables remote groups to attend lessons at their site. The starting point for the implementation of the presented model has been to improve learning by networking didactic material for students enrolled in the first course of C programming Language.

A Web site has been implemented, devoted to the course, in order to allow students to access material and to form discussion groups. According to the proposed model, the material consists on a set of didactic modules structured in the following atomic components:

- A lesson, that includes a downloadable and printable file of presentation and imposes a sequential reading structure.
- A set of exercises, provided for the lesson. Solutions are also provided in order to allow students to compile and running programs at their sites.
- A test consisting in self-evaluation quizzes with predefined multiple answers and automatic feedback. As finally assessment, the student is presented the list of his correct answers. Wrong or null answers are also showed and the corrected answer is suggested.

5. Conclusions

Because the consistence with live lectures, the students appreciated the availability of didactic modules whose distribution through the Web allows to go over a lesson again. The on-line material is beginning the main reference for the course and, even if it cannot be considered as an electronic book [2], its adoption exhibits many advantages with respect to a paper book. Specially, it promotes a virtual classroom because students at different locations share and interact within a common educational environment.

6. References


