

Authoring Adaptive Educational Hypermedia in WINDS

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Abstract:

Web-based Intelligent Design and Tutoring System (WINDS) is a European project¹ with the objective to implement a learning environment integrating an intelligent tutoring system, a computer instruction management system and a set of cooperative tools. This environment will be used to build a large knowledge base supporting Architecture and Civil Engineering Design Courses and to experiment a comprehensive Virtual University of Architecture and Engineering Design. In this paper we present the basic concepts of the system, the design of its authoring environment as well as the strategy to implement adaptation and personalisation.

1 Introduction

The main objective of WINDS is to contribute to the reorganization of the pedagogical, cultural, and functional aspects of design education at the university level. The traditional approach to design teaching shows some frequent problems that increase learning time and reduce knowledge retention. WINDS will provide support instruments for a pedagogically more adequate approach to design teaching. As far as contents are concerned, the system will focus on the problem of cultural integration. In the first year of the project together with the 21 content providers basic requirements for a web-based system supporting design teaching were collected. Based on these requirements a first specification of the WINDS authoring and learning environment was done. The WINDS system provides a new methodological approach to design education on the web. The main benefits of WINDS courses are seen as

- general advantages of e- learning, such as worldwide access to learning material and contact to teachers, independent personal working times, well- tested material reused
- focus on teaching professional skills (not only textbook knowledge) by means of specialized tools and the integration of best practices
- support for cooperation among students (peers) as well as between students and teachers
- special support for course authors, such as semi- automatic index creation, and the facilitation of creating learning objects with a corporate WINDS style from templates

From a pedagogical point of view the WINDS platform mainly wants to support:

- the easy creation of flexible learning objects, which can be reused in a variety of learning contexts and different curricula
- the flexible and personalized creation of goal based learning materials and courseware comparable to [1]

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- the semiautomatic connection of multiple learning activities concerning design artefacts and dynamic learning objects (individual learning, cooperative learning)
- the connection of a closed knowledge corpus provided by the teacher, with the open and dynamic learning resources in the WWW, and a living repository of knowledge from the community of learners.
- the integration of workplace software [2] and meta-cognitive learning tools [3]
- various relations between learning objects
- a sophisticated learner model which allows for performance evaluation and interest and preference learning
- coaching activities on a course and document level

For reaching those goals we have taken into account several of the existing standards and semi standards on learning objects, learner models and their storage and exchange for example [4, 5]. We think that the representation approach for reusable learning object is the main prerequisite for building personalized courseware. By the approach we will describe in the following sections the WINDS learning environment will be able to do personalization on learning object presentation, learning object sequencing and the dynamic linking between different learning objects. Therefore in this paper we introduce the fundamental concepts and learning objects used in the system. Second we will describe the WINDS integrated authoring environment and the strategy to implement adaptation and personalisation features in the system.

2 Learning objects

Considering the amount of information that will be collected in the WINDS university we realized that storing and collecting the material in a reusable way is essential. Based on the analysis of several approaches to formulation of reusable learning objects (for example [6]) we defined the WINDS learning objects to fulfil several purposes:

- to be the basis for a consistent content generation by the WINDS system
- to enable for a maximum of reusability of learning objects
- to allow for a maximum of flexibility for the dynamic generation of online lessons and courses

The WINDS content management and authoring tool supports authors in building independent learning objects and structuring them in a default course hierarchy. Nevertheless the underlying knowledge representation and storage allows for reusing and handling learning objects independently and combining them in new dynamically generated courses later on. This assures that the system is able to produce individualized courseware for students depending on their current state of knowledge, their preferences and learning styles. Based on the current definition of learning objects the system allows for generating adaptive educational hypermedia courses with personalized curriculum sequences and personalized content selection on a level of units and pages.

The basic building blocks in the WINDS system should provide the basis for consistent content generation with maximal flexibility for dynamic generation of online courses. This means the key feature required from these building blocks is their reusability.

Following these aims four basic types of learning objects are defined in WINDS:

- *Course Units* are top-level elements that have only subunits but no super-units.

- *Learning Units* provide the means for course structuring (comparable to Reusable Learning Objects in Cisco's RLO- RIO structure [6]).
- *Learning Elements* are the basic chunks of information with templates for different pedagogical purposes.
- *Index Terms* are the fundamental terms of a common glossary for a course.

All these learning objects can be associated with a subset of the Learning Object Metadata defined in the IEEE LOM specification [4]. The course authors can also specify basic relations between learning objects based on a subset of the Dublin core recommendations [7]. These will include prerequisite relations, *part_of*, and *related_to* relations between course units, learning units, and learning elements. Additionally all WINDS learning objects in a course unit will be linked dynamically by the underlying index defined by the course authors. Each learning element has its own didactical goal and the authors can select from a set of pre-defined templates or create their own paragraphs by using a basic paragraph template.

3 Authoring environment

The main components of the authoring interface are the navigation tree on the left side and the content frame on the right side of the screen (Figure 1). The navigation tree gives an overview of all courses authored (*Courses to teach*) and additionally all the learning elements created by the author can be listed (*Pool of Learning Elements*). Additionally in the learning element pool authors can search for related topics and learning units created by other authors and share their learning objects with them. A course has three main folders presented on the left side of the page under *Courses to teach*:

- The *Units* folder includes all the learning units and learning elements forming the structure and content of the course.
- The *Index* is at the beginning a universal department index prepared in advance and chosen by the author who can enhance it.
- The *Documents* are supplementary sources of information relevant to the course. Specialised portals with up-to-date materials can be referenced here.

The *Pool of Learning Elements* contains all the learning elements created by the author in the system. These materials can be reused.

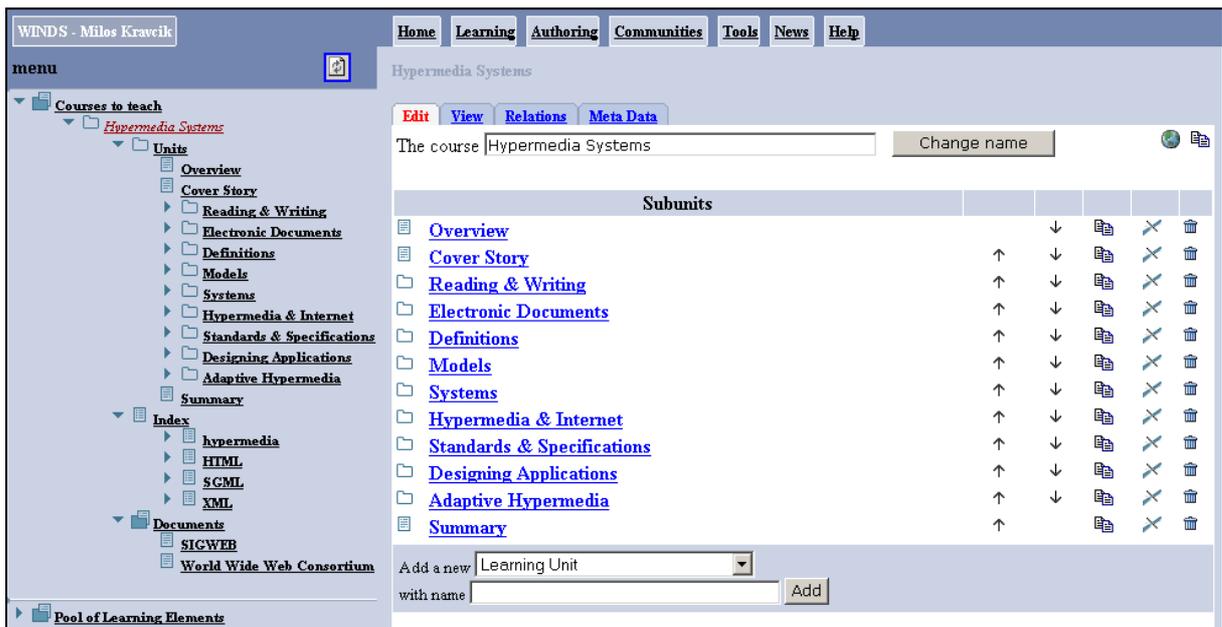


Figure 1: Editing a learning unit in the WINDS authoring environment

On the right side of the screen the content of the chosen course is displayed (Figure 2). For the author the following forms are provided and are accessible via different tabs:

- *Edit* to change the structure and content of the course. The learning objects can be added, moved, copied, disconnected or deleted within the course structure. The author can publish the current learning unit and copy it to a buffer as well as edit the learning elements.
- *Terms* (just for learning elements, not for learning units) to show the content of learning elements or (external) documents with index term entries highlighted and displaying the corresponding term descriptions on demand.
- *View* to display the learning objects in the same way like students will see them.
- *Relations* to specify prerequisite units and alternative versions in other languages.
- *Meta Data* to provide information related to Learning Object Metadata [2] (general, life cycle, technical, educational, rights).

4 Course content

The starting point for course authors should be to consider the available study materials for the course, since the main part of their work is organising and editing the course contents, which will often consist of materials that already exist. As mentioned above the system distinguishes three types of learning objects: *Course Units*, *Learning Units*, and *Learning Elements*. The first two types are folders that enable structuring the course materials. The latter one means the actual course material, which is divided into three subgroups:

- *Paragraphs* - the contents of the course
- *Exercises* - the practice tasks in a course
- *Tests* - the course assessment

The author can include *Paragraphs*, *Tests*, *Exercises*, *Discussions*, and *Documents* (external resources, further readings) into the course. Furthermore, each course contains an *Index*, where the author can define terms and relations among them.

4.1 Paragraphs

Paragraphs are content elements that can be of different types reflecting their expected educational purpose and structure. The author can choose either a general paragraph type - *Basic Paragraph* with arbitrary number of content blocks - or one of the paragraph types according to the CISCO specification [5].

All paragraph types consist of reusable content blocks that can have different pedagogical functions. In the paragraph templates all of the paragraph elements can be provided as a text (ASCII or HTML) typed into the template, or an imported file, or a given URL that is just a link to a page not integrated into the course (Figure 2).

Complex paragraphs combine several elements with different pedagogical functions to fulfil a pedagogical goal. The following list gives an overview of pedagogical functions for content blocks:

- *Introduction* – establishing the purpose of the paragraph
- *Issue* – a problem to be solved
- *Fact* – unique, specific, one-of-a-kind piece of information
- *Definition* – an identification and explanation of a concept
- *Example* – a good representative of the concept
- *Non-example* – an easily confused example of a related concept
- *Simulation* – an interactive presentation of the concept
- *Process* – a staged table, block diagrams, or cycle charts showing a flow of events
- *Procedure* – a sequence of steps to be followed or decision rules to be considered
- *Guidelines* – to make judgements
- *Criteria* – to compare different constructions
- *Analogy* – related to audience's background
- *Instruction notes* – special lecturer notes for live classroom teaching
- *Summary* – recapitulation of the learned skills, suggestion of further readings and learning objects

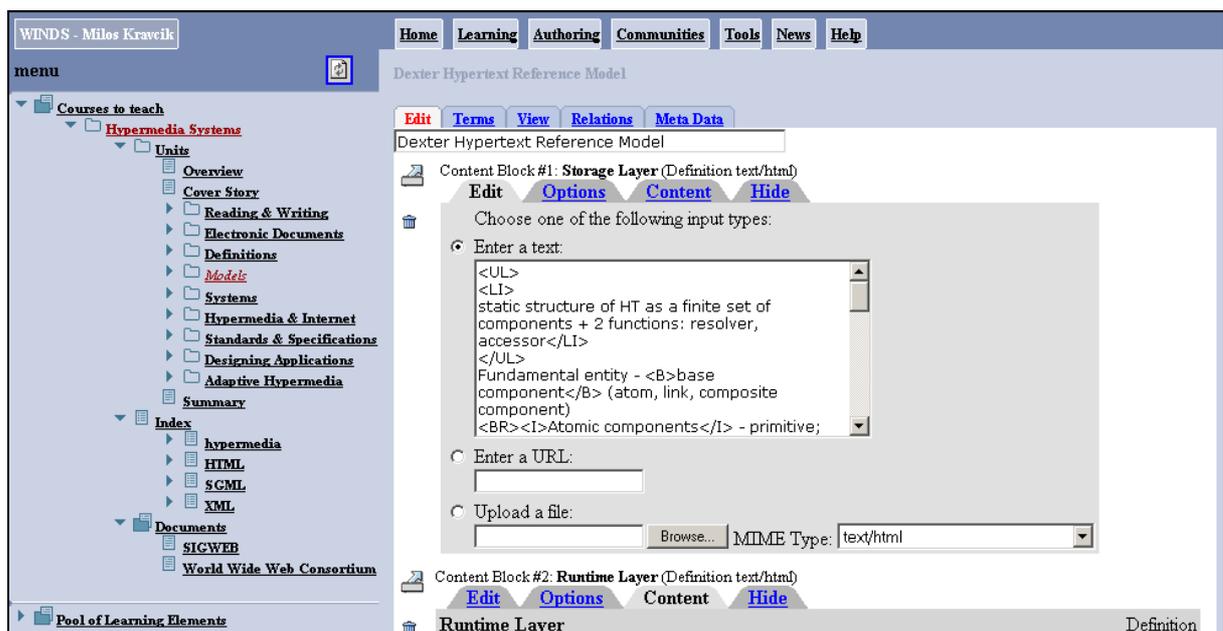


Figure 2: Editing a learning element in the WINDS authoring environment

4.2 Tests

Tests are assessment elements to measure the knowledge of the students. The system has its own *Test Editor* that enables editing templates for each test type. Currently the author can select from several types (Text Single Choice Test, Text Multiple Choice Test, Picture Single Choice Test, Picture Multiple Choice Test). In a test editor the author specifies the question and possible answers. Each answer item consists of the following parts:

- *True?* - the indicator whether the answer is correct or not
- *Item text* - the text (and picture in the latter two cases) forming the answer itself
- *Follow up text* - the text obtained by the student after choosing this item
- *Charged object* - the learning object that is in charge for the item
- *Actions* - the button to remove the item

4.3 Index Terms

Index terms provide means to interrelate heterogeneous course contents and to find individualised paths through the learning materials. The WINDS course index component allows the maintenance of index terms together with their respective definitions. Furthermore, the author can specify relations of different types (e.g. *is_a*, *part_of*, *related_to*) between terms, allowing for a graph like exploration of terms and their definitions.

The index component can retrieve and highlight occurrences of index terms within the course materials as well as within registered external documents (such as web sites). This behaviour greatly simplifies the authoring process: the course author simply has to define the set of index terms relevant to this course (or, even simpler, use one of the predefined indexes) while the system realises the task of retrieving occurrences and linking terms to occurrences and vice versa.

Especially the possibility of registering external documents (web sites) to the index, offers simple possibilities to include dynamic contents of external providers into a course: the index component can annotate the external documents and link occurrences of index terms back to the term definitions within the course.

5 Creating adaptive courses

Up to now we have described the authoring environment. But to explain how the learning objects will be used to provide adaptive courses we need to mention also the *learning environment* that will be used by the students to access the WINDS courses. A key component of the learning environment is the *user model* representing the student's knowledge of the domain, her goals, experience and preferences. The course structure and the user model enable flexible adaptive navigation and content presentation at various levels in the WINDS learning environment. The structure of a course is defined hierarchically by means of learning units and learning objects. Among them various relations are defined, like prerequisites, *part_of*, *related_to*. Comparing the user model with these relations the structure of the course as well as navigation through the course can be dynamically adapted for the user.

Adaptation is realized also on the level of learning elements that are created as sets of content blocks with defined pedagogical roles and other metadata. Based on the current user model, the relations between learning objects and roles of the content blocks the learning environment can adapt presentation of the learning elements.

5.1 User model

The user model is a part of the learning environment. The complete history of the educational events for each user is recorded. These events are called *user episodes* and include the user's operations with the learning objects, all evaluations of her work by teachers and system as well as all inferences of the system about her knowledge level. On the base of the user episodes the system generates the user model so that it always reflects the current state of the user's progress. The information is available both for the teacher to control the student's study process and for the system to adapt the course presentation and navigation for the student. From the implementation point of view the user model resides on the server side so the users can connect from various machines without losing their identity data.

5.2 Adaptive structure and navigation

The learning objects in a learning unit have a predefined order according to which they are presented by default. As the learning objects have also relations with other learning objects and metadata defined, the default sequence can be adjusted to the current needs according to the user model. In this way various adaptation methods can be adopted, including guidance and orientation support. These methods can be implemented by such adaptation techniques like direct guidance, link sorting, link hiding, or link annotation.

5.3 Adaptive content presentation

Students view the course content accessing the learning elements that consist of content blocks. Each such chunk of information has a predefined order, pedagogical role and other metadata. These are attributes according to which such adaptation methods like additional explanation, prerequisite explanation, comparative explanation, explanation variants, or sorting, can be implemented taking into account the user model. In this way the system can adapt the sequence of content blocks according to the chosen learning strategy. For instance a concrete example can precede or complement an abstract statement if the student needs it. The pedagogical roles of the learning elements as well as those of the content blocks can be also expressed graphically, for example by different background colours to reduce the cognitive overhead of the learners.

6 Sharing a common understanding

The course index with the occurrences of terms enables students to study more systematically and gain clear understanding of the specific expressions during the course. A course index is a list of the terms and their synonyms from the course together with their occurrences within the course and optionally also outside of the course, on the web. After the author has decided on the terms to be included in the index, the occurrences of terms in course material can be detected automatically for text based formats (ASCII, HTML, XML) (such as paragraphs, tests). Creating always a completely new course index would be very time consuming, therefore every department providing courses provides one standard course index. These standard department indexes are available for authors when creating a new course and can later be adjusted to the author's needs for each course. Additionally system administrators can author indices for arbitrary topics that can then be imported by course authors.

The author can also specify such relationships between learning objects like prerequisites and alternative versions of the same learning object in different languages. It can help students to choose the most suitable learning object according to their needs, abilities, skills, and knowledge later on.

7 Combining structured curricula learning and open knowledge corpus

Additionally to the basic course materials in the learning units, the author can specify also external documents relevant to the course domain. These can explain in more detail some specific issues or provide up- to- date information like specialized portals do. Such external documents serve also as resources for homeworks and projects. The teacher has the possibility to provide extra materials, which can go into more details than the course or give alternative views of the domain.

The learners are not only passive receivers of knowledge but can themselves contribute to the corpus writing private or public annotations, providing feedback to the author, or discussing course related issues with colleagues and teachers in a discussion forum. In this way students can answer some questions themselves and can cultivate their ability to formulate problems and give argumentations.

8 Summary

In this paper we gave an overview of the current state of the WINDS authoring platform for building highly reusable content for adaptive educational hypermedia courseware. One of the primary objectives of the WINDS system is to make the authoring process relatively simple and to support sharing of resources. The learning objects collected with this authoring system can be delivered in a variety of ways, from classical web-based training to combinations of classroom events and online seminars, or even as personalized books. In the next few months several of this courseware players (learning environments) will be implemented and will be evaluated in 2002. Beside the possibility for cross media publishing and the flexible combination of learning objects in individualized curricula the indexing system and the connection of the learning objects allows for personalized coaching of students. Additionally the index gives alternative approaches for navigating course materials additional to curricular structures and relates external resources to the terms defined by a teacher.

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