Adaptive e-Learning DLA Course: 
A Framework

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1 Introduction

Adaptive, intelligence or personalized e-learning is recognized as, probably, the most interesting research areas in distance learning on-line Web-based Education (WBE) (KIM, 2007; MARLOW ET AL. 2009). In particular, for the WBE LA education, so far, there are not well-defined and commonly accepted rules on how the learning material should be designed (metadata-based content development), organized in reusable Learning Objects (LO), selected and sequenced to make “instructional on-line sense” in a Web-based Digital Landscape Architecture course (WBE DLA). Hence, the goal of this paper is to shorten the gap between the established traditional e-learning management systems and the modern adaptive & intelligent WBE tutoring for the benefit of the LA education (WATSON 2009).

In particular, the proposed WBE DLA framework and methodology incorporates a number of reusable LO (related to topics which are common in LA courses, e.g. digital design) with learners’ profiles and techniques for personalized content selection and finally for adaptive course sequencing. Actually, the proposed methodology benefits from a LO’s novel metadata-based design and XML implementation with embedded LA functionality, according to the cognitive style of learning needs and preferences in LA education. The proposed learning rules are generic (i.e. domain-, view- and user-independent), hosting, accordingly, lecturing functionality for relative courses (e.g. WBE Digital Architecture or Geomatics Engineering courses).

In paper’s Second Section (WBE DLA: The Architecture) the proposed architecture for an adaptive & intelligent WBE DLA is presented. In Third Section (WBE DLA: Content Development, Selection & Sequencing) the novel metadata-based structure of the proposed reusable LO is presented and the techniques for personalized content selection and adaptive course sequencing are discussed. Finally, in Conclusions and Outlook possible future extensions are presented.

2 WBE DLA: The Architecture

In the proposed WBE DLA personalized e-learning framework, seven key WBE components (modules) have been identified, namely: (1) Data acquisition; (2) Content development (data processing based on reusable LO with metadata tags); (3) local or
Internet databases (Reusable LO repositories); (4) Personalized content selection (LO retrieval and analysis according to learners’ profiles); (5) Adaptive on-demand sequencing of the selected LO; (6) The intelligent WBE DLA course (GUI format publication); and (7) The e-Learning Management Control Software (XML or PHP coding implementation). The interactions between these seven WBE DLA modules are shown in Figure 1.

Fig. 1: Framework: The 7 main components of the proposed WBE DLA methodology

3 WBE DLA: Content Development, Selection & Sequencing

Data Acquisition
For data acquisition a number of resources could be used, like: books, Internet sources, lecturing notes, etc. (Carter 2002). Also, for this purpose some simple task-defined user-friendly GUIs are needed for the data-entry procedure (Styliadis 2002).
Didactic requirements for e-learning form the size of the reusable learning units (NOTHELFER 2009). So, the LO must be as small and concise as needed, in order to support content-authors to focused on the didactic features it contains, and then to help them to identify easily the pointers to the specific content descriptions for usability support (metadata-based pedagogical functionality).

3.1 The Reusable Learning Object

In the proposed WBE DLA the LO is the basic reusable unit and in order to be adaptive and searchable must have a metadata description. The IEEE Learning Object Metadata (LOM) standard (IEEE LTSC 2002) does not support LA topics, so a novel metadata schema is needed for the LO representation. Also, for the LO implementation, the XML markup language or the PHP scripting one, seems to be a reliable answer (Internet functionality, object-oriented programming). In particular, the XML or PHP tags make the data meaningful, so the LO items can be searched, extracted, printed in PDF, published and reused in a number of ways on demand (personalization functionality).

The proposed new metadata schema (Fig. 2) is related to the DLA LO tags and it is consisted from 5 fields with 10 ASCII characters (6 digits & 4 alphanumeric): The first 3 digits are for the LO title’s ID (100 for the Digital Design I LO; 200 for the Digital Design II LO, etc.). Following, the next 2 digits are for the specific concept’s ID (00 for a generic topic in digital design; 10 for AutoCAD; 20 for MicroStation; 30 for 3ds Max; 40 for Google SketchUp, etc.). Following, the next 1 digit is for the course level (0 for an ease e-learning course; 1 for a moderate one; and 3 for a difficult demand course). Following, the next 2 characters are denoted to e-learning course specialization (00 for a generic course; LA for a course in Landscape Architecture; AR for a course in Architecture; GE for a course in Geomatics Engineering, EP for an Environmental Policy one, etc.). Finally, the last 2 characters are denoted to required LA applications functionality (00 for generic LA applications; DD for digital design LA applications; SA for spatial analysis LA applications; EP for environmental policy LA applications, etc.).

<table>
<thead>
<tr>
<th>LO title’s ID (e.g. 100)</th>
<th>Specific Concept’s ID (e.g. 10)</th>
<th>Course Level (e.g. 1)</th>
<th>Course Specialization (e.g. LA)</th>
<th>LA Applications Functionality (e.g. SA)</th>
</tr>
</thead>
</table>

Fig. 2: The metadata schema for the reusable Learning Object

The structure of the proposed reusable LO:

- **Title**: The LO title (e.g. Digital Design I, Spatial Analysis II, Environmental Policy).
- **Generic Core Content**: The definition of the core educational concept (content) for which the LO is designed accompanied by some generic examples and applications. Also, a number of pointers -embedded intelligently into the text-should point to the specific content descriptions according to the introduced metadata schema.
- **A number of Specific Content Descriptions**: To support reusability - The detailed descriptions of specific educational concepts into the Title domain (e.g. in...
case of a Digital Design I course: Theory of design, AutoCAD tutoring, MicroStation tutoring, R/T Landscaping Architect tutoring), accompanied by some examples and applications for each description. The tags of these specific descriptions will follow the introduced metadata schema.

- **Test**: The test element used for e-learning evaluation. It includes several (e.g. 10) test items relevant to learning difficulty level and to the concept of the LO. Also, for a fair judge examination policy, the actual test item is assigned to the learner randomly by the \(i=\text{random}(1..10)\) function. So, the assessment function TEST \((i, \text{text-script})\); where: \(i=1..10\) and text-script={AutoCAD 2D; Digital Design for LA generic applications; Moderate CAD knowledge, etc.} is needed.

Figure 3 presents the XML implementation of the WBE DLA digital design I LO. It includes one title and one generic core content item (moderate level for LA e-learning with Spatial Analysis applications functionality), three specific description items to support LO reusability on demand with 2 options (2D AutoCAD, 3ds Max), and two test elements, one with a resource reference to an external XML examination file and the second one representing the way to form an examination from the available LO’s test items’ in this case the examination-test includes the test items from test03 to test06, which is the combination of all available LO’s test items related to LA spatial analysis applications functionality (i.e. the SA parameter).

```
<LearningObject Digital_Design_I="http://www...."
>Title id="100">Digital Design I</title>
<br>
<Generic_Core_Content id="100001LA00">
  <paragraph> The digital design in general ...
    AutoCAD 2D modeling … [ptr Tag:100101LASA] …
    Visualization 3ds Max … [ptr Tag:100301LASA] …
    ……</generic_core_content>
<br>
<Specific_Description id="100101LASA">
  <paragraph> AutoCAD…2D modeling....
    ……</specific_description>
<br>
<Specific_Description id="100301LASA">
  <paragraph> 3d Studio Max … visualization …
    ……</specific_description>
<br>
<TestItem identifier="testSA" identifierref="http://www.xxx.xx/exam-SA.xml"/>
<br>
<TestItem identifier="testSA">
  <beginItem>test03</beginItem>
  <endItem>test06</endItem>
</TestItem>
```

**Fig. 3:** The XML-implementation of the Digital Design I reusable Learning Object

Similar LO descriptions could be defined for Digital Design II, Digital Design III, Spatial Analysis, Environmental Policy, etc. covering the LA curriculum.
Content Development
For reusable content development a number of GUI open-source environments are available, like: (SCORM, 2003), IEEE Learning Object Metadata (LOM) standard (IEEE, 2002; http://ltsc.ieee.org), Metavist 2005 s/w which creates FGDC-compliant metadata (Federal Geographic Data Committee; http://www.fgdc.gov), OMEKA project (http://www.omeka.org), AICC (http://www.aicc.org), ADL (http://www.adlnet.org), etc. The above content development tools are generic with limited functionality for e-learning LA content development. So, for a particular WBE DLA framework, there are two options: manual data-entry or the development of some new GUI data-entry forms implemented in XML, PHP or MS-Access (STYLIADIS 2002).

Reusable LO Repositories
After the content development procedure, the reusable LO should be added to local or Internet databases or learning object repositories for collection, sharing and reusing of distributed LOs (SAMPSON & KARAMPIPERIS 2004). The proposed metadata schema, because of its simple ASCII format, could easily be adopted by these databases for an effective LO access and management (ARAPI ET AL. 2007).

3.2 The Personalized Content Selection Procedure
The Learners’ Profiles (LP) include education, background, cognitive style, learning preferences, needs, teaching & evaluation rules, and details on progress & performance in related LOs. These LPs are mapped to specific WBE selection criteria (pedagogical module), which are used as an input to e-learning management control s/w for forming the appropriate metadata pointers to the specific content descriptions. Then, the on-demand LOs are composed and, finally, a content menu for the requested WBE DLA course is dynamically synthesized (SAMPSON & KARAMPIPERIS 2004).

Pedagogical Module
In most WBE systems that incorporate course sequencing techniques, a pedagogical module is responsible for setting the principles and rules of content selection and instructional planning. In the proposed framework this pedagogical module is a part of the management control s/w, and the selection of content (i.e. the DLA learning objects) is based on a set of selection criteria according to LPs. Most of these selection criteria are generic rules (KRAMER ET AL. 2010), and there are no well defined and commonly accepted criteria on how the DLA learning objects should be selected and how they should be sequenced to make “instructional value” with LA functionality. So, in order to design highly adaptive WBE DLA systems a set of selection criteria rules is required, since the involved dependencies between the educational characteristics of the DLA learning objects and the potential learners’ profiles are very complex (ARAPI ET AL. 2007).

In the proposed framework, the metadata schema has the potential to a semantically more accurate retrieval of content data, and hence the LO selection problem could be addressed by proposing a selection criteria module as a challenge for design pedagogy (theory & knowledge), that instead of “forcing” an educational material designer to define the set of the selection rules in a traditional way; supports an on-demand metadata-based decision that actually simulates the decision process of the educator (GIRVAN & SAVAGE 2010).
3.3 The Adaptive Course Sequencing

The next step is the on-demand sequencing according to the learning LA communities. So, WBE DLA adaptive course sequencing is defined as the process that selects LA learning objects from a local database, an Intranet or a global Internet-based digital repository (i.e. huge knowledge databases with design and LA functionality) and sequence them on-demand (i.e. in such a way which is appropriate) for the targeted LA learning community or individuals interested in WBE LA. Personalized learning trends to present the LA learning objects associated with a WBE on-line course in an optimized order for sequencing (BRUSLOVSKY & VASSILEVA 2003; KARAMPIPERIS & SAMPSON 2005; CHEN 2008).

WBE-Testing & Self-Assessment

For e-learning course testing including self-assessment quizzes the following software routines are proposed (KOSTONS ET AL. 2010; LAZARIDIS ET AL. 2010):

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>test.html</td>
<td>HTML page</td>
<td>HTML form that contains the quiz questions</td>
</tr>
<tr>
<td>score.php</td>
<td>Application</td>
<td>Script to assess learner’s answers</td>
</tr>
<tr>
<td>rtf.php</td>
<td>Application</td>
<td>Script to generate an RTF certificate from the template</td>
</tr>
<tr>
<td>pdf.php</td>
<td>Application</td>
<td>Script to generate an PDF certificate from the template</td>
</tr>
</tbody>
</table>

The e-Learning Management Control Software

The following application example is used for the e-learning management control s/w (the 7th framework component) demonstration and presentation. So, supposed that:

- Learner’s profile (good knowledge of ICT; moderate knowledge of CAD).
- Learner’s needs (digital design for Landscape Architecture, AutoCAD I, SketchUp, GIS/Spatial Analysis applications functionality).
- Examination rules: University/tutor/course regulations or learner’s willing for self-re-examination (moderate, e.g. N=5).

Hence, after applying a simple mapping procedure, the information about the data (i.e. the LO metadata contents) are found; and they are the values of the pointers (pointing to specific descriptions): 100101LASA, 100401LASA. In Figure 4, the control software for the adaptive course sequencing structure in XML batch coding is displayed. Also, in the case of a PHP scripting implementation (Linux, Apache, MySQL5, PHP5), the course sequencing structure will be modular (routine-based) instead of the batch/goto programming logic.
Step | XML Implementation
--- | ---
1: | `<Title id="100">Digital Design I</title>`; counter=0; N=5;
2: | TEST (random(1..10), moderate CAD knowledge);
   if (FAILED) goto Step-13
3: | `<Generic_Core_Content id="10001LA00">` TEST (random(1..10), digital design for LA generic applications);
   if (FAILED AND counter++<N) goto Step-3
   else if (counter=N) goto Step-13
4: | … [ptr→Tag:100101LASA] … (AutoCAD 2D) goto Step-7
5: | … [ptr→Tag:100401LASA] … (SketchUp) goto Step-10
6: | `<Specific_Description id="100101LASA">`
7: | TEST (random(1..10), AutoCAD 2D);
   if (FAILED AND counter++<N) goto Step-7
   else if (counter=N) goto Step-13
8: | goto Step-6
9: | `<Specific_Description id="100401LASA">`
10: | TEST (random(1..10), SketchUp);
   if (FAILED AND counter++<N) goto Step-10
   else if (counter=N) goto Step-13
11: | END (pass); Stop
12: | END (failed); Stop
13: | Fig. 4: Control Software: adaptive course sequencing (XML batch programming)

The GUI intelligent WBE DLA course (GUI formatted publication component)
This delivery module (the 6th framework component) includes XSL files, for transforming the XML files into a number of publication documents, like: PDF documents, RTF documents, HTML files, Wiki forms, etc. So, in the WBE DLA client/server environment, every time when a request from a client for a specific content to be presented to the learner is received, this publication component invokes the right XSL file for the appropriate transformation. Hence, the on-demand content will appear on client’s browser in a user-friendly GUI format.

4 Conclusions & Outlook
The presented work, which is just a framework and not an e-learning ready-to-use system, is an attempt to address the content development and the LO selection and sequencing problem in intelligent learning systems with LA functionality. For the content development a novel metadata schema was introduced and incorporated in LO structure as a challenge for design pedagogy, so reusability is supported and the LO are designed in a highly de-contextualized manner. The proposed methodology provides the framework for designing intelligent e-learning systems in DLA, in digital architecture, or in geomatics engineering.
In future extensions, learning characteristics like content difficulty or semantic functionality, which affects both selection and sequencing of reusable LO must be defined (Karampiperis & Sampson 2005). Also, future research would related to LO intelligent selection and decomposition from existing WBE courses in similar disciplines, allowing reuse of these disaggregated LO in different disciplines (while preserving e-learning functionality and the educational characteristics they were initially designed for).

5 References


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