On a LS-Adaptive Learning Objects Creation Methodology Using LOM Metadata

Aremy Virrueta-Gordillo[1 2] , Rodolfo Ibarra-Orozco[1], Juan Carlos Lopez-Pimentel[1], and Victor Ramos-FonBon[1]

[1] Universidad Politecnica de Chiapas,
Calle J. Selvas s/n. Tuxtla Gutierrez, Chiapas, Mexico
{avirrueta, ribarra, jpimentel, vramos} @upchiapas.edu.mx
[2] Universidad Politécnica de Valencia
Camino Vera S/N. 46007, Valencia, Spain.
arvirgor@posgrado.upv.es

Abstract In this paper, we present a methodology to generate Adaptive Learning Objects based on the students' learning style orientation. An adaptive hypermedia methodology is applied in order to classify a Learning Object (LO) and, then, the obtained classification is inserted into the LO, so a Learning Management System can present the LOs that correspond with the students learning style preferences. At this current research stage, we are particular interested in developing a framework to build Adaptive Learning Objects, in which the LO and the students' learning styles are manually classified. In the following stage, we will focus on classifying these elements in an automatic way, by means of machine learning techniques.

1 Introduction

The e-learning strategy hasn't shown consistent good results. Several projects have had failed results, e.g., [1], [2], [14], and so the learning process has finished in an incomplete way. Some initiatives, with the goal of achieving the learning digital objective, have been proposed. For example, blended-learning, [13], combines classroom with digital learning courses; Castillo, [6,8], proposes a learning objects development to fit specific student features. Besides, some standards to build learning objects have been reviewed and developed in order to enable an efficient learning objects management into the Learning Management System (LMS). Automation of pedagogical tools have enhanced learning common environments and transferred this experience to virtual scenarios.

The work described in this paper merges several of the mentioned initiatives with the main purpose of defining Learning Styles-based Adaptive Learning Objects (ALO) for courses presentation through a system (LMS).

The remainder of the paper is organized as follows. Section two describes the students and learning objects interaction. Section three describes, in a general way, the LOM-IEEE standard. Section four gives an overview of the learning styles and adaptive hypermedia concepts. Section four includes a LO standards and theory learning styles theory analysis from an adaptive hypermedia system (AHS) perspective. In section five, the proposed Methodology for LOs creation based on students learning styles is presented. Finally, conclusions are discussed and future work is presented in section six.

2 Students and Learning Objects Interaction.

Learning Objects (LOs) are the fundamental entity inside e-learning courses. The IEEE LOM proposes the following LOs formal definition: A LO is "any entity, digital or non-digital, that can be used, re-used or referenced during technology supported learning", [3].

Some standards to create LOs have been proposed. These standards specify LOs as an organized metadata collection and allow LO being accessible, adaptable, interoperable and reusable for any LMS. Some Standards used to create LOs are SCORM,[3] IMS,[4] and LOM,[5]. These standards don't integrate elements that can be useful to accomplish a LO and student interaction. The IMS-LD standard, considers interaction into package elements, but the available LMSs are not yet ready to integrate such packages into courses. In this work, metadata is used to describe interaction elements between the student and the LO with the objective of generate adaptive learning objects (ALOs).

In traditional learning environments, learning content and student interaction is guided by a teacher who applies different pedagogical strategies to ensure each student learning. In an e-Learning environment, LOs must be presented to students in a carefully designed sequence to keep the students motivated by the course content and to make them feel that the learning content meets their needs. The ALO presentation involves two main steps: The ALO creation and the student preference profile detection.

In order to include interactive elements in a LO, a classification structure is specified. This classification structure is based on the dimensions of Adaptive Hypermedia Systems (AHS), where the learning styles theory is associated with the AHS's dimensions.

Next sections describe the defined LO learning style based classification and how this classifications elements are integrated into metadata.

3 Learning Object Metadata

IEEE LOM (Learning Object Metadata) is generally accepted as the standard for providing metadata to multimedia learning resources. The aim of using metadata for describing learning objects is to promote the learning material sharing.

[3] Sharable Content Object Reference Model, http://www.adlnet.gov/Technologies/scorm
[4] IMS Content Package Specification, http://www.imsglobal.org/content/packaging/cpv1p2pd2/imscp_primerv1p2pd2.html
[5] Learning Object Metadata. Learning Technology Standatds Commite, http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf

LOM uses the following categories to describe resources. These can be seen as a superset of the Dublin Core elements.

1. General: groups the general information that describes this resource as a whole.
2. LifeCycle: describes the history and current state of this resource and those that have affected this resource during its evolution.
3. Meta-MetaData: describes the specific information about the metadata record itself (rather than the resource that this record describes), who created this metadata record, how, when, and with what references.
4. Technical: describes the technical requirements and characteristics of this resource.
5. Educational: describes the key educational or pedagogic characteristics of this resource. This category stores the pedagogical information essential to those involved in achieving a quality learning experience. The audience includes teachers, managers, authors, and learners.
6. Rights: describes the intellectual property rights and conditions of use for this resource.
7. Relation: defines the relationships among this resource and other targeted resources, if there are any. Multiple relationships can be supported.
8. Annotation: provides comments on the educational use of this resource, who created this annotation and when.
9. Classification: describes where this resource is placed within a particular classification system. To define multiple classifications, there may be multiple instances of this category.

Studies about the real use of the LOM standard show that metadata is often misused or not instantiated. Such results are mostly due to the high specification complexity. Besides, some of the metadata values are subjective, so it is difficult to assign a value to them.

4 Learning Objects Classification System

To classify the LO is necessary to define a classification system that integrates a metadata standard into LOs. It is important to understand that a classification system divides a domain of reality in an ordered series of categories and subcategories. In this case the domain is a screening tool of learning preferences and categories are the learning styles that define the tool. Also, we use the dimensions that define Adaptive Hypermedia Systems (AHS) to support the identification of the elements of the classification system

4.1 Adaptive Hypermedia Systems

Adaptive hypermedia is concerned with the functionality of hypermedia, in a way that they become personalized. An adaptive hypermedia system gathers information about users and their behavior and, according to their needs, goals, settings and actual knowledge the information is adapted and then, presented in a personalized way.

Many systems are based on the principles of adaptive hypermedia, e.g., information retrieval systems, on-line information systems, on-line help systems, educational hypermedia systems, etc.

Examples of educational hypermedia systems are the ISIS-Tutor System, [5], a learning environment adaptive hypertext; The Anatom-Tutor, [4], an intelligent tutor to teach anatomy; Shaboo, [11], a tutor to teach the basic concepts of programming oriented objects; Online SHARP, [15], a system applied to solving mathematical problems. These systems use adaptation techniques for adapting the information presented to the user.

4.2 Learning Styles Detection Tools

Detection tools for learning styles identify preferred ways in which a person can learn. Each person has a learning preferred way. These preferences are grouped into styles and are known as "Learning styles", [10]. Several definitions of learning styles currently exist. Keefe, [16], defines learning styles as being characteristic of the cognitive, affective, and physiological behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment. Dunn, [7], describes learning style as "... the way each learner begins to concentrate, process, and retain new and difficult information". Morales, [17], defines learning styles as a pedagogical model for classifying student-associated cognitive issues.

Several studies have been done to detect learning styles in students, e.g., the investigation conducted by Fleming [12], which generated the VARK test,[6]; the Honey-Alonso questionnaire [7]; and the model designed by Felder and Silverman[8],[10], which was implemented by Spurlin, [11]. This latter model seems to be the most appropriate for the use in computer-based educational systems, [9]. Most learning style models classify students in few groups, whereas Felder-Silverman Learning Styles Model (FSLSM) describe the learning style in a more detailed way, distinguishing four learning style "dimensions".

- The first dimension distinguishes between an active and a reflective way of processing information. Active learners learn best by working actively with the learning material, e.g. working in groups, discussing the material, or applying it. In contrast, reflective learners prefer to think about and reflect on the material.
- Sensing-intuitive learning dimension. Learners with preference for a sensing learning style like to learn facts and concrete learning material. Sensing learners tend to be more practical than intuitive learners and like to relate

[6] VARK: A guide to learning styles, http://www.vark-learn.com
[7] CHAEA Questionnaire, http://www.estilosdeaprendizaje.es
[8] lLS: Index of learningstyles, http://www.engr.ncsu.edu/learningstyles/ilsweb.html

the learned material to the real world. Intuitive learners prefer to learn abstract learning material. They like to discover possibilities and relationships, and tend to be more innovative than sensing learners.
- The third, visual-verbal dimension differentiates learners who remember best what they have seen, e.g. pictures, diagrams and flow-charts, and learners who get more out of textual representation, regardless of the fact whether they are written or spoken.
- In the fourth dimension, the learners are characterized according to their understanding. Sequential learners learn in small incremental steps. In contrast, global learners use a holistic thinking process and learn in large leaps. They tend to absorb learning material almost randomly without seeing connections but after learning enough material they suddenly get the whole picture.

5 Our proposed LS-ALO Creation Methodology

The proposed methodology comprises four steps, grouped in two processes:

1. Classification system definition.
   - Step 1. Specification of the adaptive hypermedia dimensions.
   - Step 2. Values specification for each LO category.
2. LS-based Clasification and LO integration.
   - Step 3: Select a LO metadata standard.
   - Step 4. Insert classification data into the LO's metadata.

In the following two sections, we use an example to demonstrate how to define the classification system based on the Felder-Silverman learning style model. First, the system relates the adaptive hypermedia dimensions with the learning style model and then, we present a proposal to include the obtained classification data into the IEEE/LOM metadata.

5.1 Classification system definition

Step one: Specification of the adaptive hypermedia dimensions. Table 1 describes the association between the concepts of Learning Styles model and Adaptive Hypermedia dimensions.

Step two: Values specification for each learning object category. The LO categories correspond to the learning styles proposed by the model. The range of values for each category is determined by the student's learning style belonging level.

The Felder-Silverman categories and its belonging levels are shown in Table 2 and Table 3.

When the categories are identified and the belonging levels are stablished, we have specified the classification system.

For this example we have defined a classification system with four categories. These have a value from a defined range. The value set for each category depends on the features of LO's the content.

Table 1. Adaptive Hypermedia Dimensions

Adaptive Hypermedia Dimensions	Learning Styles Concepts	Example
Where adaptive hypermedia systems can be helpful?	In LMS to ensure that the educational content are properly presented to students	Any LMS such as .LRN, Moodle, Blackboard, etc.
What features of the user are used as a source of the adaptation?	Student profile detected from a model of learning styles.	The Felder-Silverman model that defines a profile based on styles AR, SI, VV and SG
What can be adapted?	Learning objects described by a standard and managed by LMSs.	Learning objects described by IEEE LOM metadata
What are the adaptation goals?	To provide student ALOs associated to his learning profile.	Develop algorithms for the LMS manages the ALO adaptive presentation.

Table 2. Classification Categories

Abbreviature	Description
AR	Active-Reflective
SI	Sensory-Intuitive
VV	Visual-Verbal
SG	Sequential-Global

5.2 LS-based Clasification and LO integration.

A LO is considered as an ALO when classification data is included in the specification of the LO metadata.

The following processes in the methodology involves a) selecting a LO standard and b) including classification categories as an elements' specification.

Step three: Select a LO metadata standard. It is necessary to select a LO standard to analyze metadata in detail. The result of this analysis will be the identification of metadata in which classification elements may be included.

As result of the IEEE/LOM analysis, classification category was identified as the metadata into which the classification specification can be integrated with the standard, because it describes the LO belonging to a particular classification system.

Step four: Insert classification data into the LO's metadata. This step consists in adding items to the categories of the selected LO standard. For this example, the Classification category elements used to describe the classification system are:

Table 3. Belonging Levels

Value	Belonging level
1-3	Appropriate balance
5-7	Moderate belonging
9-11	Strong belonging

- "9.2. Taxon path" is used to define the classification. This item includes other elements we have used: "9.2.1. Source"that indicates the category name of the classification system and "9.2.2. Taxon", that indicates the category value. "9.2.2. Taxon" has other elements to describe the value of the category. In "9.2.2.1. ID" is placed the belonging value. In "9.2.2.1. Enter" describes the belonging value.
- "9.3. Description" is used to indicate a description of object classified.
- "9.4. Keywords" includes keys for easy search and LOs retrieval.

By following the methodology four steps, we have an ALO classified by Learning Styles. However, in order to accomplish an easy metadata insertion, it is necesary to create the ALO through an automatic applications. Exe Learning[9] and Reload Editor[10] are applications that allow the inclusion of metadata from the user interface, so we must create the metadata which describes the ALO and let the application generate the object.

It is important to note that the responsibility for classifying the LO corresponds to the object author. The author must be informed about the classification system and the student learning relations.

6 Conclusion and Future Work

In this paper we have presented a methodology to create ALO including classification elements that will be used for the presentation of the LOs content according to the students learning preferences. Our methodology describes how to define a classification system based on a learning style model and explains how to integrate the obtained classification with the standard LO. The object classification is just one of several activities to ensure that students have access to materials that fit their learning preferences in an online course, besides, for example,it is necessary to detect the student profile and register it into a LMS, then an intelligent algorithm to relate the student learning profile with the ALO elements must be developed.

Our future work comprises three initiatives. First, the integration of learning styles models into LMSs. An prototype can be found at http://moodle.virrueta.org. Second, the development of intelligent algorithms for an adaptive presentation

[9] eXe Project, http://exelearning.org/

[10] Reusable eLearning Object Authoring and Delivery, http://www.reload.ac.uk/editor.html

of objects through LMSs, and third, to develop applications to allow authors to create adaptive learning objects in an efficient way.

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