Berlanga Flores, A. J., & García-Peñalvo, F. J. (2005). Issues in Reusable Adaptive Learning Designs. In A. Méndez, B. González, J. Mesa, & J. A. Mesa (Eds.), *Recent Research Developments in Learning Technologies. Proceedings of the 3rd International Conference on Multimedia and Information & Communication Technologies in Education m-ICTE2005. (Cáceres, Spain, June 7-10 2005)* (Vol. 3, pp. 1016-1020). España: Consejería de Educación, Ciencia y Tecnología de la Junta de Extremadura.

Issues in Reusable Adaptive Learning Designs

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Adaptive learning designs (ALD) are units of learning that contain personalized behaviour in order to provide each student with a learning experience adequate to her/him characteristics. ALD follows as a notational method the IMS Learning Design (IMS LD) specification; therefore they are composed of learning objectives, prerequisites, learning activities, method of instruction, conditions, and so on. All ALD elements are defined as separate objects in order to build-up ALD as in the *Lego* metaphor. This approach supports their exchangeability, reusability, and utilization as fill-in templates. This paper shows our proposal to define and reuse ALD using IMS LD and points out some issues about this specification.

Keywords Learning Design; IMS LD; Adaptive Learning Designs

1. Introduction

Learning design is the application of learning design knowledge when developing units of learning (e.g., lessons, courses, curriculum, etc.) [8]. Traditional approaches are based on knowledge transfer where teachers or designers, giving the content, think about the possible resources, sequence of topics, characteristics and restrictions of their particular learning environment. New trends are focused on design learning activities that promote students' knowledge transfer from real life task, and discussion and collaboration among them. Both approaches include the need of a personalized learning environment. From our perspective, Adaptive Learning Designs (ALD) could provide each student with a learning experience where s/he acquires knowledge through learning designs tailored to her/his characteristics. Additionally, we argue that ALD (as a whole and each one of its components) should be reusable and exchangeable among different lessons, courses and systems. This will help teachers to use learning designs (or components) created by them in other learning scenarios as well as use learning designs created by others. The aim of this approach is to guarantee personalization and reusability of ALD. As a result, students will interact with learning designs adapted to their characteristics, and institutions and teachers will save time and money.

This paper presents our proposal for defining ALD using the IMD Learning Design specification [6]. The rest of this paper is structured as follows: section 2 briefly explains IMS LD and its characteristics of personalization and reusability; section 3 presents ALD; section 4 mentions issues on IMS LD, and section 5 gives conclusions and further work.

2. IMS Learning Design (IMS LD)

IMS Global Consortium Inc. (www.imsproject.org) is an organization that gathers several software and hardware companies, universities, research centres, and institutions with the aim of identifying and defining specifications to annotate metadata of learning components in order to be able to exchange and reuse them. This consortium is defining an e-learning framework that includes, for instance, specifications to annotate learning resources metadata (IMS LOM) [7] or content packages (IMS CP) [5].

IMS LD belongs to this framework. Its objective is to describe formally any design of the teaching-learning process. Specifically, it aims at meeting requirements such as completeness (to describe fully

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the teaching-learning process), pedagogical flexibility (to be able to express all kinds of pedagogies), personalization (to perform adaptation based on learner's preferences, portfolio, pre-knowledge, and/or educational needs), interoperability (to be able to exchange and use information among different applications), and reusability (to re-use learning elements in other contexts) [6].

IMS LD has three levels of implementation and compliance that are complementary (but not independent from each other): Level A contains the vocabulary to support pedagogical diversity, Level B adds properties and conditions to Level A, and Level C adds notifications to Level B.

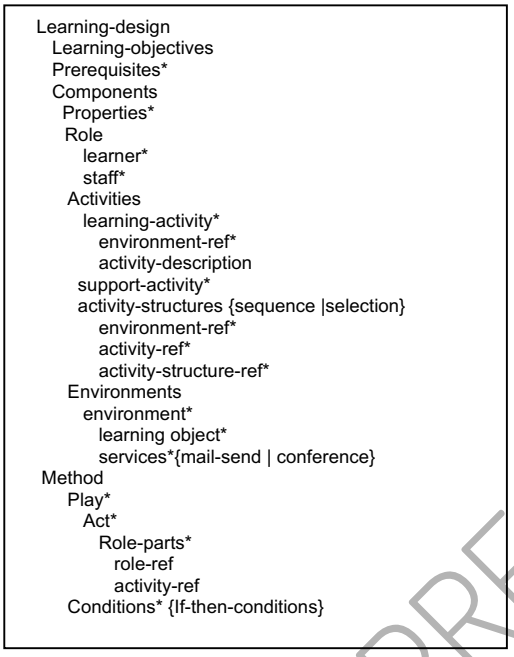

Fig.1 Hierarchical order of the IMS LD elements. The asterisk (*) means that an element may occur more than once.

Fig.1 shows the hierarchical order of IMS LD elements (abridged). A learning design modelling in IMS LD contains objectives, prerequisites, components (properties, roles, activities, sequences) and a method of learning. The latter is formed by a play, which represents the "learning flow", and conditions (if-then-else statements) that define the behaviour of the method.

Notice that IMS LD models the learning and teaching process but it does not include learning resources. That is to say, it separates the learning process structure (i.e., pedagogy) from the resources (i.e. content). As a result, a learning design should be included in a Unit of Learning (UoL) (preferably compliant with IMS CP), which is a complete learning unit (e.g., course, lesson or curriculum) that contains a learning design and its related resources (e.g., test, learning resources, URI, etc.).

2.1 Reusability and IMS LD

In this context, reusability means to be able to use an educational component or resource in different UoL, educational scenarios or delivery e-learning systems. IMS LD separates learning activities from their learning resources; this is a key factor to guarantee reusability. For instance, a learning design can be repopulated with different resources or components for use it in new learning contexts [11], or a set of learning activities can be packed in different courses [10].

2.2 Personalization and IMS LD

One of the most promising characteristics of IMS LD is its ability to annotate adaptation characteristics based on learner's preferences, portfolio, pre-knowledge, and/or educational needs.

Although, IMS LD Level A contains slight personalization options such as selections of learning activities, IMS LD Level B should be used to define personalization characteristics, and more elaborated sequences and learning interactions based on students' portfolios.

IMS LD Level B includes elements as *properties* to store information about users, *global elements* to set and view the information of the properties, *monitor services* to read the properties, and *conditions* to manage and change properties values [9].

We propose to use IMS LD to model Adaptive Learning Designs (ALD). In the next section this concept is introduced.

3. Adaptive Learning Designs (ALD)

An ALD is a learning design that considers students' characteristics (i.e., knowledge, learning styles, etc.) to adequate the learning flow that will be delivered to each student [2]. In order to permit reutilization, ALD are compliant with IMS LD. Therefore, ALD aim at combining the personalization and reusability characteristics of IMS LD.

The definition of an ALD follows the *Lego* metaphor. Each element of an ALD (i.e. learning activity, property, condition, learning objective, prerequisite, etc.) is defined as separate object. This allows authors to reuse and interchange a complete ALD, but also each one of its elements in different learning contexts, lessons, and courses.

Fig.2 represents an ALD example (inspired on [12]). It shows how ALD elements are assembled to build the UoL *Hypermedia Introduction*. It includes a personalization property (*P-Initial-Knowledge*) to store the student previous knowledge about the subject. This property is integrated in a condition that takes into account the value of this property to display a background learning activity (LA1) or an introduction about hypermedia (LA2).

There are three kinds of reusability of an ALD:

- An ALD as a template where authors could fill-in learning resources, properties, learning activities, conditions, etc. For instance, the Fig.2 example could be considered as an ALD template if activities LA1.doc and LA2.html are removed. Then authors can populate them with the learning activities or resources they want.
- Exchange components of an ALD among other ALD. The *Lego* metaphor allows authors to define UoL using components defined previously. For instance, in the Fig.2 example the learning activity L1 (Background of Hypermedia) can also be included in a different UoL as an activity about the evolution of the World Wide Web. Likewise, the condition "IF P-Initial-Knowledge < THRESHOLD" can be included in several UoL's.
- Change an ALD for new settings. For instance, in the Fig.2 example an author can also define a property that contains the final knowledge (e.g., "P-Final- Knowledge"), and then use its value in the conditions section to show complementary learning activities if the P-Final-Knowledge value is less than the threshold value.

3.1 Definition of ALD

In order to make use of IMS LD to depict the teaching-learning process, we are developing an authoring tool to define ALD. We are extending the functionality of a tool for creating hipermedia books called Hypermedia Composer (HyCo) [4]. Our objective is to support authors on the creation of learning designs by means of a tool, which does not prescribe any instructional approach, variables or conditions for adjusting learning to students' characteristics. As a result, we are developing an ALD Editor that includes the definition of IMS LD elements such as learning objectives, roles, learning activities, and so

on. Moreover, definitions of personalization properties and adaptive rules that will be considered to adjust the learning design will be available:

- Personalization properties contain information about the users. To define them authors indicate their name, data-type, restrictions, and initial-value. There are not restrictions about properties; authors can define whatever they want. Afterwards, they can include personalization properties into adaptive rules. The Fig.2 example includes a personalization property named "P-Initial-Knowledge".
- Adaptive rules are prescriptions defined by authors that will be taken into account to adjust the learning design. They contain conditions and actions (if-condition-then-action formalism [1]) that can include learning design elements, personalization properties, logical and relational operators. An expression-builder tool will support authors in the definition of adaptive rules. They can save their adaptive rules and included them into other learning designs. The Fig.2 example contains the adaptive rule (IF "P-Initial-Knowledge" <THRESHOLD).

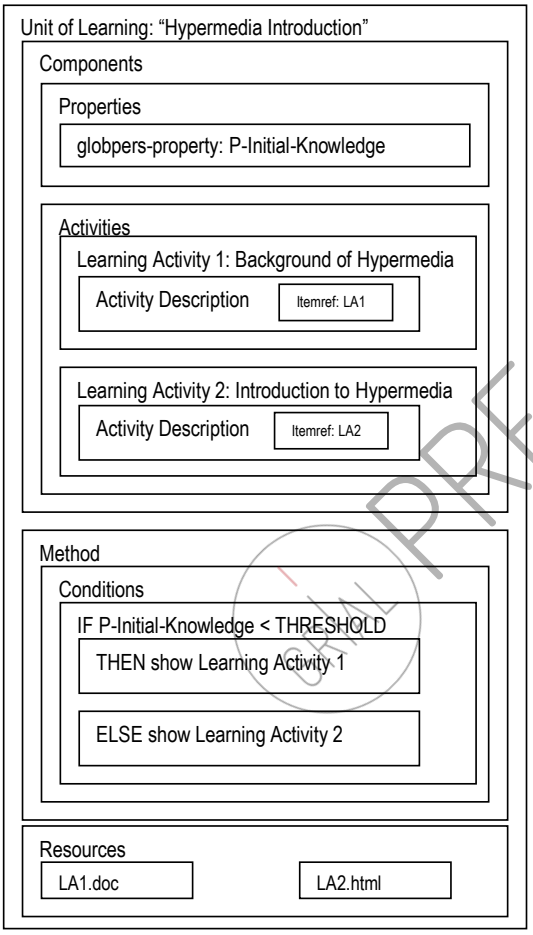

Fig. 2 Example of an ALD personalization strategy using IMS LD. Only the parts of the UoL relevant to the adaptive strategy are shown.

4. Issues on IMS LD

Although, one can argue that the use of IMS LD can be restrictive for designing learning processes, its inclusion in the definition of an ALD may bring the following benefits:

- Incorporation of an existing annotation (i.e., ontology) to describe learning knowledge and pedagogical strategies.
- Assure the separation between pedagogical strategies, adaptive logics, and contents.

- Feasible reutilization and interoperation of learning elements and learning designs among applications and systems compliant with IMS LD.
- Quick incorporation of resources and learning design components in different courses, lessons, and applications.
- Rapid creation of courses repopulated with a variety of learning activities created for other courses.
- Uniformity in the learning design if institutions provide an ALD to teachers or authors.

However, at present there is an open issue about the level of reusability of a learning design. Downes [3] argues that learning designs cannot be reusable as they are created for a specific learning experience where specific learning resources are picked for precise contexts. Koper [8] admits that is premature to determine the reusability level of an IMS LD structure (e.g., act, learning activity, method of instruction, etc.). The latter is due, in part, to the lack of authoring tools, repositories and systems compliant with IMS LD.

Moreover, although IMS LD can be used to model and annotate ALD, designing more complex adaptivity behaviour might be not so easy. For instance, in the current version of the specification it is not possible to nest learning designs (to show students' progression) or to define students' roles that consider their characteristics (e.g., knowledge, preferences, etc.). Towle and Halm [12] argue that in IMS LD it is difficult to support multiple overlapping interactions, enforce the learning flow, and change the learning strategy once a IMS LD package has been delivered.

5. Conclusions

IMS LD is language for modelling UoL and its components. It is pioneer specification that is in its early phases of development and adoption. Undoubtedly, research on its potential to define, reuse and personalize learning designs is needed, as well as projects for supporting and promoting its use. The EU funded initiative UNFOLD (www.unfold-project.net) is a significant step in this direction.

This paper presented a proposal to define ALD using IMS LD and pointed out some of the open issues and weakness of IMS LD. Currently, we are finishing HyCo LD Editor Level A. The next steps are to develop an expression-builder tool for supporting authors in the definition of the adaptive rules. Subsequently, we will test ALD reusability among systems or applications compliant with IMS LD.

Acknowledgements Adriana Berlanga thanks the Mexican Council of Science and Technology (CONACyT) for its support.

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