A Proposal to Define Adaptive Learning Designs

Adriana Berlanga, Francisco J. García

University of Salamanca, Spain
{solis13, fgarcia}@usal.es

Abstract. In this paper we outline a framework to describe adaptive learning designs where definitions as the instructional design method, the type of tests, the learning style approach, and the adaptive rules are not prescribed. IMS LD is used to guarantee the reusability and interoperability of the elements. The framework also proposes to adjust the learning design taking into account the knowledge and learning style of the learner, and the learning style of the activities by means of adaptive rule definitions.

1 Introduction

Adaptive Educational Hypermedia (AEH) is a challenging research area that may help to improve the learning of the students, adjusting contents and navigation alternatives to their characteristics. However, to teach implies more than deliver content and paths; it is a process where learners gain knowledge and skills interacting with learning resources, activities, and other students. Learning designs details this process, considering learning goals, prerequisites, and expected outcomes to indicate learning activities, sequences and learning materials.

We intend to use learning designs as the key element to perform adaptivity in AEH, where the same learning goal can be reached by every student using learning strategies tailored to her/his knowledge and learning styles, and also, to define those strategies as semantic elements –guided by a standardized metadata– in order to make it possible their exchangeability and reusability.

For these reasons, we are defining a framework –based predominantly on the IMS Learning Design specification [4]– to configure adaptive learning designs, where the instructional design method, the type of tests, the learning style approach, and the adaptive rules are not prescribed, but open to be defined by authors of the learning experience. This framework is within an ongoing research towards the definition of AEH based on learning technology specifications [2].

In the next section we outline the framework we are developing. In section 3, we expose conclusions and describe further work.

2 Adaptive Learning Designs

We propose to define adaptive learning designs modularizing their (1) learning styles, (2) tests, (3) learning designs, and (4) adaptive rules. In the rest of this section we introduce these definitions.

2.1 Learning Style Definition

Learning styles, which establish indicators on how learners perceive and process information, might be helpful to design learning materials suitable to the way each learner learns. The Kolb's Experiential Learning Theory [6] is a well-known example of a learning style approach. It proposes four dimensions to characterize the way the student perceives information (theorist and activist dimensions) and the way s/he process it (reflectors and pragmatist dimensions).

Nevertheless, the proposed framework does not prescribe any learning style. We argue that different learning style approaches should be used for different fields of knowledge and types of students. Therefore, authors will use the learning style definition to specify the approach they judge is more appropriate for content and context. A learning object (based on the IMS LD {itemmodel}[1]) will be created for every learning style definition, in order to make it available to be (re)used in other learning designs.

For instance, Fig.1 shows the learning style element of the Kolb's Theory and its four dimensions. Later on, authors will use this learning style definition to depict the learning style of the students and learning style of the activities, as well as to define learning style tests.

```
<learning-style>
  <item identifierref="RES-ExpKolb" identifier="LSD_Kolb">
    <title>Kolb´s Learning Style</title>
    <item identifier="LSD_Kolb_Theorist"><title>Theorist</title></item>
    <item identifier="LSD_Kolb_Pragmatist"><title>Pragmatist</title></item>
    <item identifier="LSD_Kolb_Activist"><title>Activist</title></item>
    <item identifier="LSD_Kolb_Reflector"><title>Reflector</title></item>
  </item>
</learning-style>
```

Fig. 1. Definition of a learning-style element

2.2 Test Definition

In the definition of tests, authors will describe assessments to measure the knowledge and learning style of the students. There are four types of tests: learning style, initial knowledge, current knowledge, and final knowledge. The students' results on these tests will set values that could be stored in the student model, or be used to define adaptive rules (see adaptive rule definition below), and connect them with the learning style of the activities. Also, they can be included, at run-time, in the IMS LD element <globpers-property>[2] to represent the learner's learning style and knowledge.

For instance, to define the learning style tests, we can say that the CHAEA [1] instrument will be used. The other test could be defined using IMS QTI [5].

---

[1] Group element that contains three main elements: title, item and metadata.

[2] Global personal property (portfolio-property) element used for personalization that has a different value for every user. Property operations can refer to it to operate on the value [4].

2.3 Learning Design Definition

The learning design definition will be modelled in IMS LD. Therefore, authors describe the pedagogical approach of the adaptive learning design defining its learning objectives, prerequisites, roles, outcomes (learning and support activities), environments (learning objects and services), and the method of instruction.

Effective instructional strategies might involve learning styles [7]. Consequently, they are included in the definition of activities and integrated in the learning design definition. For instance, Fig.2 shows, partially, the learning design definition of the "adaptive hypermedia lesson". It contains the learning activity "AH taxonomy" annotated a Kolb's learning style definition.

```
<learning-design identifier="LD-Adaptive-Hypermedia">
  <learning-objectives>
    <item identifier="LOB-AH-lesson" identifierref="RES-LOB-AH"/>
  </learning-objectives>
  <components>
    <roles>
      <learner identifier="R-learner"/>
    </roles>
    <activities>
      <learning-activity identifier="LA-AH-taxonomy">
        <learning-style>
        <item identifierref="RES-ExpKolb" identifier="LSD_Kolb">
        <item parameters="value,70%" identifier="LSD_Kolb_Theorist"/>
        <item parameters="value,10%" identifier="LSD_Kolb_Pragmatist"/>
        <item parameters="value,10%" identifier="LSD_Kolb_Activist"/>
        <item parameters="value,90%" identifier="LSD_Kolb_Reflector"/>
        </item>
      </learning-style>
....
```

Fig. 2. The definition of the learning activity "AH taxonomy"

2.4 Adaptive Rule Definition

The proposed framework is intended to make use of the authors' pedagogical approach and expertise on the knowledge field, and give them freedom to decide what characteristics and variables should be considered to perform adaptivity.

Therefore, authors will be provided with a formalism to define adaptive rules, which adjust the learning design to the students' characteristics and to the nature of the knowledge. The definition of adaptive rules starts with the description of adaptive statements that can be saved as adaptive techniques or students stereotypes [2]. Adaptive statements are defined as (BNF notation):

<**adaptive-statement**> ::= IF <condition> THEN <action> (**1**)

<**condition**> ::= <element-set> [<unitary-op-set>] "("<expression> ")"[<binary-op-set> <condition>] (**2**)

<**expression**> ::= [<spec-element> ","] [<value> | <binary-op-set> "," <value>] ["," <relational-op-set> "," <value>] (**3**)

<**action**> ::= <action-set> "(" <expression> ")" [<binary-op-set> <action>] (**4**)

<**spec-element**> ::= specific-element-identified-by-its-id (learning-design-structure-set; student-set) (**5**)

<**value** > ::= [<data-set> |<integer> | <string> | <percentage>] (**6**)

Table 1 shows the sets that can be included in the adaptive statement definition. These elements have been defined based on the IMS LD schema group {expression}[3]. Likewise, other IMS LD elements had been considered as, for instance, prerequisites, learning-objectives, or learning activities. Furthermore, we also considered actions like show-hide (from the <`conditions`> element), and attributes of the <`activity-structure`> element as sort and number-to-select.

Table 1. Collection of sets to describe Adaptive Statements

Name of the set	Sub-set	Elements
element-set	learning-design-structure	Prerequisite; Learning-objectives; Learning-activities; Activity-sequence; Support-activity
	student-element-set	Student
data-set	learning-style-set	Learning-style
	student-data-set	Initial-knowledge; Current-knowledge; Final-knowledge
	attributes-data-set	Completed; Visited; Recommended; Sequence; Selection
	time-data-set	Time-unit-of-learning-started; Date-time-activity-started
logic-set	binary-op-set	And; Or
	unitary-op-set	Not
relational-set	relational-op-set	Greater-than; Less-than ;Equal; Greater-or-equal-than; Less-or-equal-than
action-set		Show; Hide; Show-menu; Hide-menu; Sort-ascending; Sort-descending; Number-to-select

The objective to define these sets is twofold. First, to take advantage of IMS LD possibilities, and be able to exchange and reuse the definition of adaptive rules within different learning designs. Second, to give authors a simple formalism to define adaptive statements.

For instance, by means of the collection of sets, authors could create an adaptive statement that establishes that, if the initial knowledge of the student is less than 50%, a menu will show the prerequisites of the learning activity, as in the following statement:

IF Student (initial-knowledge, less-than, 50%) THEN show-menu (prerequisites) (**7**)

Adaptive statements could also consider the learning style of students and activities. For example, in the following rule, the initial knowledge of the student, her/his learning style, and the learning style of the activity (i.e. 10% of the Kolb's theory dimension "Pragmatist") are taken into account:

IF Student (initial-knowledge, less-than, 50%) AND Student (learning-style, "Pragmatist", greater -than, 10%) AND learning-activity (learning-style, "Pragmatist", greater-than, 10%) THEN show-menu (prerequisites) (**8**)

Afterwards, authors could use an adaptive statement as an adaptive technique or student stereotype. For instance, an adaptive technique, which configure the

[3] It includes operators (calculation, logical), references (learning activity, activity structure, etc.) and other elements to define conditions (If-then-else statements) [4].

behaviour of the system when students are interacting with the learning design, could consider the student knowledge to show a menu with the prerequisites (as in formula 7):

TECHNIQUE <guidance> = IF Student (initial-knowledge, less-than, 50%) (**9**)
THEN show-menu (prerequisites)

Likewise, a student stereotype, which allows authors to group students considering one or more characteristics, could be defined for formula (7) as:

STEREOTYPE <beginner>= IF Student (initial-knowledge, less- than, 50%) (**10**)

3 Conclusions and further work

In this paper we sketched a framework to describe adaptive learning designs where its description is open to define learning style approaches, tests, adaptation rules, and learning designs.

Currently, we are extending the functionality of HyCo, an application we developed for authoring hypermedia books, to utilize it as the learning design authoring tool [3]. The next steps are to analyze if test will be modeled with IMS QTI, and to design how the adaptive rule definitions will be generated and integrated into an IMS LD file. Then, we will test if adaptive rule definitions could work in learning designs compliant with IMS LD and vice versa.

Acknowledgments

Adriana Berlanga thanks the Mexican Council of Science and Technology (CONACyT) for its support. Research supported by the Castile and Lion Government, Spain (ref. SA017/02, US09/05).

References

1. Alonso, C., Gallego, D., Money, P.: *Los estilos de aprendizaje: procedimientos de diagnóstico y mejora*. Mensajero, Bilbao, Spain. 2002.
2. Berlanga, A., Garcia, F.: An Open Model to define Adaptive Educational Hypermedia Systems based on Learning Technology Specifications. In *Int. Workshop Web Semantics, (WebS 2004), in conjunction with DEXA 2004* (Spain, 2004) IEEE (forthcoming).
3. Garcia, F.J., Berlanga, A., Moreno, M., Garcia, J., Carabias, J.: HyCo – An Authoring Tool to Create Semantic Learning Objects for Web-based E-Learning Systems. In *Int. Conference Web Engineering, (ICWE 2004)* (Germany, 2004) LNCS Springer-Verlag.
4. IMS Learning Design Specification v.1.1. 2003. <www.imsglobal.org>.
5. IMS Questions and Test Interoperability Specification v.1.2. 2002. <www.imsglobal.org>.
6. Kolb, D.: *Experiential Learning: Experience as the Source of Learning and Development*. Prentice-Hall, Inc., Englewood Cliffs, N.J. 1984.
7. Merrill, D.: Instructional strategies and Learning Styles: Which takes Precedence? In *Trends and Issues in Instructional Technology*. Reiser *et al*. (Eds.), Prentice Hall. 2000.