An Adaptive Meta-model for E-learning

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ABSTRACT
In order to propose new approaches for e-learning environments and enhance their possibilities, we propose a model to authoring adaptive learning designs. This model will allow teachers, instructional designers, and experts, to define: the learning style approach they consider is more adequate giving the characteristics of the topic; the assessments and tests that will be used to evaluate the students' understanding of the topic; and, the adaptive rules, adaptive techniques and students' stereotypes that will be used to tailor the learning materials to the learners' characteristics. The model also contains an adaptive meta-model that has two intentions. The first is to audit the coherence of the adaptive rules created by the teacher. The second is to evaluate if those rules have been effective to learn the learning material taking into account the performance of the learners.

Categories and Subject Descriptors
H.5 [**Information Interfaces and Presentations**]: Hypertext/Hypermedia, User Interfaces.

General Terms
Algorithms, Measurement, Design, Experimentation, Standardization.

Keywords
Adaptive Hypermedia Systems, Learning Technology Standards, Authoring Adaptive Hypermedia, Learning Design.

1. INTRODUCTION
In the last years, several educative institutions had incorporated information and communication technologies into the educational process in order to increase the quality and dissemination of the Education.

This incorporation has emerged a great variety of e-learning environments. However, the result of this e-learning explosion is that the same contents, instructional designs, and didactic materials are delivered to students who have different characteristics, knowledge, and learning styles.

Moreover, broadly speaking, e-learning elements are designed and presented without any division between its content and its meaning. This syntactic presentation prevents to automatically extract data [1]. In this context, interoperability, reusability, and interchange among e-learning systems are impossible. Additionally, the idea of a cost-effective development is far away.

Giving this situation, and with the aim to develop and improve the possibilities, characteristics, and services provided by the e-learning environments, we consider significant to study, in one hand, how different educational contents and instructional designs can be adapted to the diversity of students, an in the other, which is the process that has to be followed to determine the efficiency of the adaptive rules used to perform adaptivity. The goal is to help students to reach their learning goals in less time with better results by designing adaptive e-learning environments based on an open model. The model is directed to define adaptive e-learning environments with characteristics configurable by teachers or instructional designers.

Moreover, we intend to use learning technology specifications to describe learning elements, this will provide them of a semantic meaning and will make them interchangeable elements that can be used in several e-learning environments, or be used by agents.

2. OBJECTIVES
The general objective of the thesis is to propose an open model to define adaptive e-learning environments. The model will give the possibility to define the learning style, the learning design, the adaptive rules, and the tests that will be used to build and deliver an adaptive learning experience to each student. The specific objectives are divided into the following items:

1. To develop an adaptive learning environment based on the open model proposed
    a. To provide students of an effective e-learning tool to help them to reach their learning objectives. This tool will be able to adequate the contents, and links to the learner knowledge, and learning styles.
    b. To provide professors of an authoring tool to create configurable adaptive e-learning designs.
2. To develop an Adaptive Meta-Model
    a. To resolve if the adaptive rules defined by the professor are coherent and can be performed.
    b. To determine if the adaptive rules designed by the professor have been effective (i.e. students had learnt in less time with better results).
3. To evaluate the proposal
    a. To define and apply an experimental design based on study cases, and provide conclusions and improvements.

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3. DESCRIPTION

The initial architecture of the model (see Figure 1) has five models (or sub-models): the Learning Domain Model, the Student Model, the Adaptation Model, the Interaction Model, and the Adaptive Meta-model.

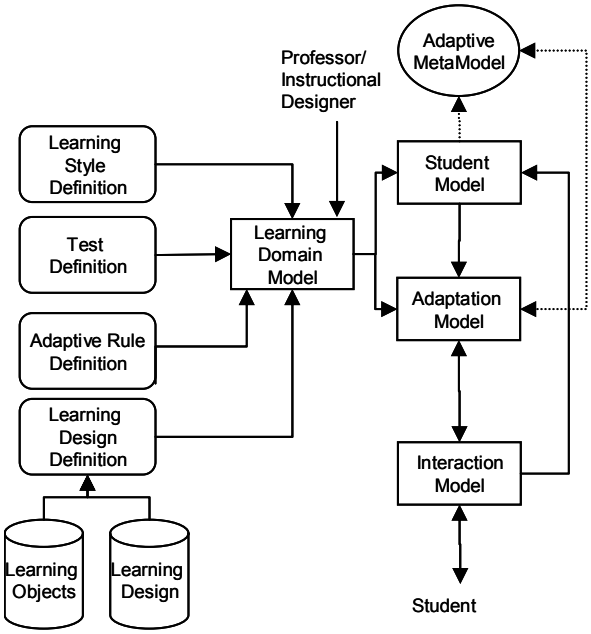

Figure 1 - Architecture

Various specifications defined by IMS (www.imsproject.org) are used to describe the metadata of the elements. Namely, the IMS Learning Design (IMS LD) [12] is used to label the Learning Domain Model; the IMS Content Packaging (IMS CP) [11] is used to define the Interaction Model; and the IMS LOM (IMS LOM) [14] is used to annotate the repository of learning objects

3.1 The Learning Domain Model

The Learning Domain Model includes the learning style definition, the test definition, the adaptive rule definition, and the learning design definition.

3.1.1 Learning Design Definition

The objective of the learning design definition is to specify and describe the knowledge structure and the learning instructional design. The approach of the proposed model is based on the learning activities. This is to say, instead of describe learning concepts, the learning experience is structured into learning activities.

The definition of the learning design is guided by the IMS LD specification. The main elements of this specification are: learning-objectives; prerequisites; components (roles, activities, environments), method, and metadata. These elements will be used to describe the learning design definition. To create activities there are three elements available: learning-activity, support-activity and activity-structure. We propose to use these elements as elements that can be adapted.

The learning style of the activities will be considered to perform the adaptation. Further, it is important to have the possibility to consider that an activity could cover all the dimensions of a learning style approach but in different percentages. The attempt is to open the scope and not state that just one learning style dimension can be covered in one learning activity or sequence. Consequently, the element learning-style will be added to the definition of learning activities to store, as a vector, what learning styles the activity endorse. The vector contains the learning style dimensions and the percentage the element covers for each learning style approach. Although this element is not considered in IMS LD it will be added.

3.1.2 Learning Style Definition

Learning styles attempt to establish indicators on how learners perceive, process and interact with learning environments. Considering these indicators it is possible to design learning materials and instructional designs more suitable to the manner each learner learns. However, there is much discussion of learning styles [16] and a lack of consensus.

As a result, many learning style approaches had been defined. There are some that are appropriate only for a specific field, like the Felder and Silverman Learning Style Model [7] that is directed only for engineering education. This approach proposes ten dimensions. Two related to the way students receive the information (sensorial-intuition), and the other eight related to the way the information is processed (visual-verbal; inductive-deductive; active-reflexive; sequential-global). Other well known approach to define learning styles is the Kolb's experiential learning theory [15] that also takes into account the way the information is perceived (theorist and activist dimensions), and the way the information is processed (reflectors and pragmatist dimensions).

Nevertheless, to construct an open model it is necessary not to prescribe one or other approach. The idea is not to set down any learning style, but a flexible structure where the different learning style approaches can be described and used to characterize the learning style of learners and activities. This description also will be considered to perform the adaptation.

Therefore, by means of the learning style definition the teacher or instructional designer specifies the learning styles approach that would be considered. For every learning style it is necessary to define its name, description and dimensions.

3.1.3 Test Definition

In the test definition the tests and assessments that will be used are described. There are four types of tests: learning style, initial knowledge, current knowledge, and final knowledge.

The objective of the learning style test is to identify the learning style of the student. This type of test should be linked to a learning style definition created before, that will provide the dimensions of the learning style that will be measured. This test is defined by its name, description, linked learning style definition, and sets of questions that correspond to each dimension of the learning style definition.

The objective of the initial knowledge test, current knowledge test, and final knowledge test is to measure the students' knowledge. The initial knowledge test and the final knowledge test have to be linked to a unit of learning (or lesson), while the current knowledge test has to be associated with a learning activity or activity sequence.

The results of these tests set the values of the learning style, initial knowledge, current knowledge, and final knowledge of each

student. These values are used to describe adaptive rules and, consequently, they will be used by the Adaptation Model to determine what activities are adequate to the student, taking into account his/her learning style and knowledge.

3.1.4 Adaptive Rule Definition

While in most cases the definition of adaptivity is pre-defined by the designers of the adaptive systems, in the proposed model the objective is to give teachers and instructional designers' freedom to define what characteristics and variables have to be considered to perform the adaptation and avoid programmers and designers decisions on what features are more suitable for describe the adaptation, what are the characteristics of the different adaptive techniques, or if stereotypes should be used to perform adaptivity.

Adaptive rules define the conditions that will be considered to execute an action or actions to adapt the content and links to the students' characteristics. Conditions can include the prerequisites, learning objectives, learning activities, activity sequences, as well as the learning styles that describe these elements. Moreover, characteristics of the student as his/her learning style, initial knowledge, current knowledge, final knowledge, or his/her interaction with the learning material (behaviour) can be used. Actions can include hide or show a learning element or a menu with certain items; sort elements; recommend, or not recommend elements; consider if learning material will be presented in a sequence or in a selection manner; or if a number of learning activities have to be performed to consider the learning activity as completed.

3.2 The Student Model

The student model stores all the information of the learner that can be helpful to adapt the content and links. It contains the learning style, initial knowledge, current knowledge, final knowledge, and information of the students' interaction with the content (e.g. visited pages).

Students not only have 100% of one learning style, but a mix of them. Therefore, we propose to store –as in the description of the learning style of learning activities– all learning styles that a student has (i.e. he/she has answered a learning style test) in a multidimensional vector where each layer represents a learning style approach. Within each layer is stored the percentage the student has for each dimension of that learning style approach.

3.3 The Adaptive Model

The adaptive model integrates all the definitions of the learning domain model (learning design, test, learning style, adaptive rules) to automatically generate the learning content and paths that will be presented to each student.

3.4 The Interaction Model

The objective of the Interaction Model is twofold: to deliver an adaptive unit of learning for each student (IMS CP is used to annotate the file: this is the integration of the IMS LD into the IMS CP, and is the way of interchange learning designs), and to observe behaviour of the student while he or she interacts with the learning material. Observation includes data about what learning activities the student visited and the results of the four types of test (initial-knowledge, current-knowledge, final-knowledge, learning-style). This information will update the student model.

3.5 The Adaptive Meta-model

The Adaptive Meta-model aim is to audit if the adaptive rules defined by the teacher or instructional designer are succeed in providing an effective learning to students. This model will take into account the time the student spent to complete the learning activity and his/her grades in the different tests.

Moreover, this model will verify if the definitions of adaptive rules are coherent, well constructed, and do not interfere with other definitions.

4. CURRENT STATE OF THE WORK

We are developing an authoring tool based on the open model outlined in this paper. We are making use of an authoring tool for compose hipermedia books called Hypermedia Composer (HyCo) [8] [9]. The idea is to extend its capabilities and build an adaptive e-learning environment to test and develop the proposed model.

At present time, we are developing the leaning domain definition of the open model.

5. CONCLUSIONS

Although, research in the adaptive educational environments has been done for many years, some well known examples are ELM ART [4], InterBook [3], AHA [6], KBS-Hyperbook [10], and TANGOW [5], the utilisation of an open model that configure the behaviour of the adaptive learning environments, at present, is not developed.

For that reason, we consider valuable to propose an open model directed to fulfil the requirements of teachers or instructional designers in such way that it will be possible to design learning environments for any knowledge field, educational level, instructional design or learning style. In addition, the model will give teachers the possibility of build their own adaptive rules and audit their efficiency.

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7. REFERENCES

[1] Berners-Lee, T., Hendler, J., Lassila, O. The Semantic Web. *Scientific American* (February 2001).

[2] Brusilovsky, P. Methods and techniques of adaptive hypermedia. *User Modeling and User-Adapted Interaction* 6, 2-3 (1996), 87-129.

[3] Brusilovsky, P., Eklund, J., Schwarz, E. Web-based education for all: A tool for developing adaptive courseware. In *Proceedings of Seventh International World Wide Web Conference*. Computer Networks and ISDN Systems 30 1-7 (1998), 291-30.

[4] Brusilovsky, P., Schwarz, E., Weber, G. ELM-ART: An intelligent tutoring system on World Wide Web. In *Intelligent Tutoring Systems*. Frasson, C., Gauthier, G.,

Lesgold, A. (Eds.) LNCS 1086, Springer-Verlag, 1996, 261-269.

[5] Carro, R, Pulido, E., Rodríguez, P. TANGOW: Task-based Adaptive learNer Guidance On the WWW. in *Proceedings of the 2nd Workshop on Adaptive Systems and User Modeling on the WWW (ASUM99). 8th International World Wide Web Conference*. (Toronto, Canada, May, 1999).

[6] De Bra, P., Calvi, L. AHA: a Generic Adaptive Hypermedia System, in *Proceedings of the 2nd Workshop on Adaptive Hypertext and Hypermedia* (Pittsburgh, USA, June 20-24, 1998) 5-12.

[7] Felder, R. M. and Silverman, L. K., Learning and Teaching Styles in Engineering Education. *Engineering Education*, *7*, 78 (1988), 674-681.

[8] García, F. and García, J. Educational Hypermedia Resources Facilitator. *Computers & Education*. Elsevier Science. ISSN 0360-1315 (accepted).

[9] García, F., Carabias, J., García, J., Berlanga, A. HyCo: An authoring tool from semantic educational resources. In *Proceedings of Second International Conference on Multimedia and Information & Communication Technologies in Education (m-ICTE2003)* (Badajoz, Spain, December 3-6, 2003), Junta de Extremadura, Spain, 2003, Vol. III. 1670-1674.

[10] Henze, N., Nejdl, W. Adaptivity in the KBS-Hyperbook System. In *Proceedings of the 2nd Workshop on Adaptive Systems and User Modeling on the WWW (ASUM99). 8th International World Wide Web Conference*. (Toronto, Canada, May, 1999).

[11] IMS CP. IMS Content Packaging version 1.1.3. 2003.http://www.imsglobal.org/content/packaging/index.cfm

[12] IMS LD. IMS Learning Design Specification version 1.1. 2003.http://www.imsglobal.org/learningdesign/index.cfm

[13] IMS LIP. IMS Learner Information Package Specification version 1.1.3 2003. http://www.imsglobal.org/profiles/index.cfm

[14] IMS LOM. IMS Learning Resource Metadata Specification version 1.1.2. 2001. http://www.imsglobal.org/metadata/index.cfm

[15] Kolb, D. Experiential Learning: Experience as the Source of Learning and Development. Prentice-Hall, Inc., Englewood Cliffs, N.J. 1984.

[16] Merrill, D. Instructional strategies and Learning Styles: Which takes Precedence? In *Trends and Issues in Instructional Technology*. R. Reiser and J. Dempsey, Eds., Prentice Hall. 2000.