Enriching Learning Standards to Support Authoring of Re-Usable Self-Assessment Activities

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Abstract: - In this paper we present a number of new structures to enhance the design of adaptive self-assessment in the already existing engineering approaches, concerning specifications and standards for re-usable learning design. The structures are designed having in mind the self-assessment modeller of AWAIT (Author for a Web-based Adaptive Intelligent Tutor), trying to study the opportunities afforded by the IMS Learning Design (IMS-LD) specification in order to make AWAIT's self-assessment design available as re-usable learning material.

Key-Words: - Authoring tools, Educational Adaptive Hypermedia, Teaching Strategies, Educational Modelling Languages, Learning Design

1 Introduction

Building large hypermedia applications is difficult, and is further complicated by the fact that, once an application has been built, its maintenance is correspondingly more complicated. Moreover, as in other software domains (such as information systems, databases etc.) hypermedia applications are usually built from scratch. Adaptive Hypermedia (AH) is an alternative to the traditional "one-size-fits-all" approach in the development of hypermedia systems [1]. AH build a model of the goals, preferences and knowledge of each individual user and use this model throughout the interaction with him/her, in order to adapt to the needs of that user [2]. It is quite natural that educational hypermedia was one of the first application areas for AH. Hypermedia applications for education need a large number of people such as programmers, instructors and experts in content design to be involved in their design thus making their construction a complex and time-consuming task. The use of Educational Adaptive Hypermedia (EAH) is probably more extensive than that of their stand-alone ancestors Intelligent Tutoring Systems (ITSs) and Hypermedia Systems (HS) because of the popularity of Internet, but still if there are no standards facilitating the learning design and no opportunities for reuse of existing learning objects and learning designs, the systems' development would become too costly and more important unable to take advantage of the existing educational experience in the field. Moreover, if there are no authoring environments facilitating a continuous updating of the content, then the systems would soon become out-of-date, offering no interest to their users any more. An approach to simplifying the systems construction and to make their reuse not just a dream is the development of web-based authoring tools based on standards for both content construction and learning design [3].

Towards this direction, in the field of Learning Management Systems (LMS) the learning objects movement has grown over the past few years, and is becoming increasingly a mainstream. Several specifications and standards for learning objects exist, and there is much interest in meta-data and packaging for re-usable educational content. The combination of Simple Sequencing and the CMI model in Sharable Content Object Reference Model (SCORM) 2004 standards [4] does facilitate limited adaptivity. However, the only available data for the user model are the data in the fixed CMI model. The data that can be set by the active learning objects are also limited to the CMI model. Alternative or more complex approaches to adaptivity such as those adopted by EAH, concerning mainly the adaptability of the

educational process to the needs of the user, are therefore not possible within SCORM 2004. Recently, Koper [5,6] proposed a new approach focused on educational modeling in order to increase and improve the use of technologies in the educational process. This approach permits the description of learning situations with educational meta-model languages. Koper's research led to the specification of EML (Educational Modelling Language) notation system, which formed the basis for IMS Learning Design (IMS LD) 1.0. was approved as an IMS Final Specification on February 2003.

In parallel, as long as the field of EAH was moving to a more mature state with a good number of established and evaluated adaptation technologies, the focus of research has gradually moved from creating more and more new AH technologies to the problems of design and authoring of AH systems. This is also the case with the authoring tool called AWAIT, that serves as agent of WADIES [7]. The WADIES is an AEH for compilers teaching through Web, where the student can navigate through the electronic books chapters, be assessed using tests of various difficulty levels and self-assesses his comprehension level of the basic domain concepts. The framework of WADIES proposes an innovative and novel perception for self-assessment, regarding the teaching strategies used. Central to WADIES are the beliefs that a teaching strategy should be 'freed' from the elements that are responsible for 'driving' it and that developing/grouping of teaching strategies operating in the paradigm of multiple teaching strategies, is congruent to a common set of beliefs, which are responsible for 'driving' them [8].

As AWAIT is a no IMS LD aware software, central to our research, is to study the opportunities afforded by the IMS-LD specification in order to make AWAIT's self-assessment design available as re-usable learning material.

In the next paragraph we will present the new trends in the field of learning modelling language. Next, we will discuss in brief on the architecture of the AWAIT system and how the strategy modelling component of AWAIT has been desiged. Then, we will proceed with the the conceptual vocabulary of a new notation system called Adaptive Hypermedia Meta-model (AHM), based on the IMS-LD specification. The AHM is especially designed to permit the re-use of the strategy component of any EAH system authored by AWAIT or any other authoring tool respecting the same educational principles. Finally, we will draw some conclusions about the way such an authoring tool, adopting the standard specifications for content and learning activities, stands up for the adaptability of an EAH, and finally we will present out future goals for enriching structures in AHM in order to support adaptivity more effectively.

2 The IMS Learning Design specification

The IMS LD meta-model revolves around describing 'units of learning'. These are atomic or elementary units providing events for learners, satisfying one or more inter-related learning objectives. In a unit of learning, people act at different roles (staff members or students) in the teaching-learning process. In these roles, they work toward certain outcomes by performing learning and/or support activities within an environment, consisting of learning objects and services to be used during the performance of the activities. The approach separates learning objects and services from the educational method used in the unit of learning [6].

The method is designed to meet learning objectives and presupposes certain prerequisites. The teaching-learning process is modeled in the method on the notion of a theatrical play. A play has acts, and in each act there are one or more role-parts. The acts in a play follow each other in a sequence (although more complex sequencing behavior can take place within an act). The role-parts within an act associate each role with an activity. The activity in turn describes what that role is to do and what environment is available to it within the act.

Since IMS LD separates the approach to learning from the learning objects and services used, opportunities occur for re-use but also for extension with structures supporting adaptivity. Responding to this challenge we try in our research to extend IMS LD meta-model enriching it with structures that could support successfully most of the adaptive technologies.

3 The AWAIT system

AWAIT, is an acronym that stands for Author for a Web-based Adaptive Intelligent Tutor. AWAIT is a no IMS LD aware software, designed as an authoring tool for a typical EAH called WADIES. Central to the conceptual model of WADIES is the

notion of Learning Style. Learning Style depicts the educational system's set of beliefs which drive the assessing procedure. Each educational action should be designed according to these beliefs. The intentions of an educational system are a subset of the learning objectives of the learning interaction. These objectives are often the deep comprehension of a specific concept in the domain which results from a successful self-assessment activity. When the learning objectives are difficult to be reached, then intentions are consisting possible alternative objectives using alternative teaching strategies. A Learning Style should group together multiple teaching strategies encompassing the same teaching beliefs.

A teaching strategy is represented by a triple generic structure, method, tactic(s), action(s). A method is a mechanism for structuring the knowledge in order this to be appropriate for the implementation of a teaching strategy. Well-known teaching methods are for example the Method of Example, the Method of Correlation, the Method of Analogy, etc. A teaching strategy usually implements a specific teaching method using different tactics to support the learner in achieving the learning objective. For example, if the system uses analogies for tutoring, it may change the teaching tactic from implicit to explicit, or anything in between, in order to help the student in answering correctly an exercise. However, alternatives at the method level are considered to be different teaching strategies because a method characterizes uniquely a strategy. The knowledge-objects of activities included in a teaching strategy design should respect the appropriate structuring for the corresponding method and tactic. The activities of a teaching strategy come along with the actions that have to be taken after the successful or unsuccessful implementation of each of them. An action, is a low level activity such as display this message, show this example, etc.

The system's underlying architecture is shown in Figure 1. The two main authoring components, namely the Course Modeller and the Self-Assessment Modeller, hold the system's modules dealing with courseware construction and self-assessment construction respectively. In this paragraph we will present in brief only those characteristics of the system which concern the design of the exercises and of the style of self-assessment.

3.1 Exercises Designer

The exercises designer allows the authoring of exercises in the form of structured html documents. Except from the body of the exercise and the corresponding answer, a message which will support the student in case of a wrong answer, should be added too as proposed by [9, 10]. Finally, the teacher must declare the method under which the exercise will operate so that the right exercise structure will be activated through design.

The self-assessing methods that AWAIT uses in order to produce exercises for WADIES are the: a) Method of Example, b) Method of Correlation and c) Method of Analogy.

A self-assessing strategy is characterized not only according to the method it follows but also

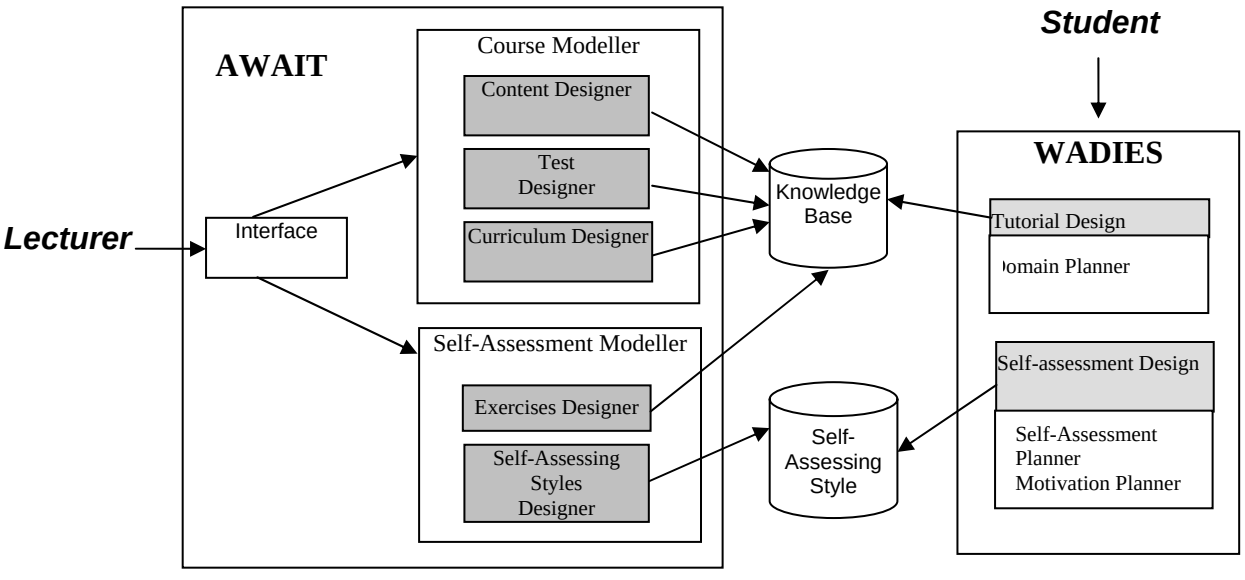

Figure 1. The architecture of AWAITS

secondarily according to the tactics each method should comprise. In exercises design, the lecturer defines under which tactic each help message coming along with this exercise will operate. For example, a help message coming with an exercise based on the method of correlation could have been created in the implicit dialogue tactic, while another coming with the same exercise could have been created in an explicit dialogue tactic, e.g. the first message could give a hint to the student and the second could give him the right answer explaining in the same time the reasons why it is considered as right.

Exercises concerning the same concept, operating under different methods but receiving the same answer are considered as related and form a self-assessment unity for that concept. WADIES flexibility for effective self-assessment is based on the availability of exercises of different methods comprising different tactics in the self-assessment unities.

3.2 Self-assessing Styles Designer

A self-assessing strategy is concerned with the structure of the used method and the interaction of that method with the student.

The lecturer should define a new self-assessing strategy by choosing one from the existing methods and a number of tactics under that method. Then, she designs a self-assessing style by grouping multiple self-assessing strategies together. Therefore, different combinations of methods and tactics, at both levels, result in a number of self-assessing strategies.

We can conclude that styles should not comprise exactly the same set of methods, but methods could comprise the same set of tactics. Given the task of self-assessing a concept, there is more than one manifestation both at the method level and the tactic level. The definition of styles ensures that only the congruent manifestations between these different methods and their tactics are grouped together.

4 Conceptual Framework and Vocabulary of AHM

We will now describe the conceptual framework of the Adaptive Hypermedia Meta-model (AHM) notation system which is widely inspired by IMS LD, trying to enrich it with structures, supporting some of the adaptive characteristics of AEH.

AHM supports the adaptive techniques of Brusilovsky's taxonomy [11] combining the different structures to implement a range of adaptive hypermedia techniques. The main structure of AHM is the unit of learning, as in IMS LD. The Learning Style Design replaces the Learning Design structure of IMS LD, which now includes an association of one or more Teaching Strategy (TS) structures in order to offer a rich instructional environment and to meet requests concerning adaptation.

The general modelling technique of AHM follows that of the IMS-LD model. The new structures included in AHM are the 'Teaching Strategy Design' structure, the 'Chain Object' and the 'Link Object'.

We also made a few changes to the Learning Design structure of IMS LD leading to the 'Learning Style Design', to the Located Learning Objects structure leading to the 'Knowledge Object', and to the 'Global Personal Properties' structure where new important attributes about the learner's performance, attitudes and motivation have been added.

Services and the remaining structures are the same as in IMS-LD.

In the next paragraphs we present an overview of the basic conceptual terms present in the Adaptive Hypermedia Model (AHM). It is not our intention that these structures be exhaustive, more that they provide enough richness to support adaptivity at the pedagogical level.

4.1 Learning Style Design

The central idea here is to design a learning style structure according to which the educational system has the freedom to apply a number of alternative teaching strategies until the learners reach the overall learning objectives of a unit of learning.

In order to achieve the desired functionality the model does not restrict learners to follow the learning activities in a given order as IMS-LD does. In contrary, instead of depicting a strict sequence of learning activities during teaching style design, the designer simply refers to an object of a new type, called strategy-chain, where the default sequence of alternative teaching strategies is described. In this way the learning style structure is designed independently from learning activities and has to do only with the sequence in which the existing teaching strategies will be applied by the system

when a new unit of learning is presented to the learner at runtime.

4.2 Teaching Strategy Design

In our approach, the Teaching Strategy (TS) is used to represent a teaching strategy like the one designed in AWAIT. Each TS is represented by a TS structure, where the strategy's method, tactic(s) and action(s) are explicitly referred.

The TS structure determines which role gets which activities at what moment in the process, similarly to the method structure in the IMS LD model. If the activity contains an exercise or a self-assessment question then the tactic that the system should implement, has to be declared too.

4.3 Chain Object

The chain object offers to the designer of the educational process the potential for adaptive modelling. A chain object is a structure that depicts a set of alternative teaching strategies or activities to be presented in sequence. There are two types of chain: strategy-chain and knowledge-chain.

In a strategy-chain the sequence of one or more of teaching strategies is denoted. Teaching strategies are implemented at runtime in sequence, until the overall educational goal or the existing sub-goals are reached. Strategies in the chain are linked together using the link object that permits their re-sequencing in any sequence that fits better the learner's profile.

A knowledge-chain provides the mechanism to structure activities and activities-structures into a sequence. Activities or activity-structures in a knowledge chain are associated by links (loose or strict) determining the curriculum sequencing. Loose links among them permit their re-sequencing according to the learner's preferences, performance, motivation or aptitudes. A knowledge chain could be used to implement Brusilovsky's 'Adaptive link sorting' and 'Inserting/Removing Fragments'[11].

4.4 Knowledge Object

The knowledge-objects are the located learning objects of IMS LD. They represent any piece of media like text, image, graphic, video, etc., now enriched with attributes necessary for supporting adaptation to the learner's model. The more important of these attributes are: the Method-Tactic, the Level attribute, the Weight attribute, the Context attribute and the Difficulty attribute.

The Method-Tactic attribute attached to a knowledge-object indicates for which method and tactic this object has an appropriate structuring. The Level attribute indicates for which learner's profile, concerning his/her knowledge level, this data item is appropriate. The Weight attribute indicates how important this knowledge-object for the educational process is. The Context attribute indicated whether a knowledge-object will be visible or not to a learner with a specific profile concerning standard characteristics of him/her, like language spoken, personal preferences, etc. The Difficulty attribute shows the difficulty level of a knowledge-object, very important property especially in the case of an exercise or assessment or self-assessment questions.

Thus, the knowledge-objects can be manipulated by any technique from Brusilovsky's taxonomy in order to adapt the presentation and the navigation support to the learner.

4.5 Link object

Links are associations between a learning object and one or more other learning objects or other associations. There are strategy-links, semantic-links and navigation-links.

Strategy-links have an important attribute attached to them, called loose attribute which by default is "no", indicating whether the links in the strategy-chain may change from a teaching strategy to a different one from that declared during teaching strategy design. When the Strategy-links loose property is "yes" then, in runtime, the AEH is free to adapt the educational process to the learner's learning style. For example, if the learner's profile indicates that the learner's achievement is always better when the system uses a teaching strategy that is third in sequence in the strategy-chain, then this strategy could be moved at the first place of the chain.

In Semantic links the loose attribute indicates whether the link may change from a learning object to another during a curriculum sequencing adaptation procedure.

Navigation links have context attributes attached to them, indicating whether they should be visible or not according to the learner's profile. For example, a link could be authored with a context attribute that specifies that it will be only visible to an expert. Navigation link structures could be used

to implement any of the 'Adaptive link Hiding' techniques described by Brusilovsky.

4.6 Global Personal Properties

Levels B and C of the IMS LD specification support local-personal properties and global-personal properties. In AHM the local properties are declared in the learning style design and cover all the range of properties needed for recording information about the learner concerning his/her performance, aptitudes and motivation.

In order for users to be able to set and view properties at runtime, global elements are provided as a separate part of the specification. The view-property element shows the property value of a specified property and the set-property element enables a user control in a Web interface to change the current value of it. Thus, with these two elements the learner's profile is always accessible and up to date giving valuable information to any adaptation procedure.

5 Conclusion and future work

While both the LMS and the EAH communities existing largely independently of each other, there are many areas where crossover could yield new research directions and offer solutions to common problems. In this paper we propose a new metadata model based on the reasearch on adaptive hypermedia technologies, to structure the domain and the pedagogical knowledge of an educational adaptive hypermedia.

The adaptive Hypermedia Metad-model (AHM) notation system proposed in this paper provides the means to implement a wide range of adaptive technologies. However, it neither completely covers the taxonomy, nor provides the best programming solution in every situation.

We believe that EAH systems implementing the AHM model will have an advantage in that they may handle adaptation consistently across different techniques and media, thus offering their users authoring means to develop effective learning environments.

Both WADIES and AWAIT systems are still under internal evaluation. A full external evaluation is in our future goals. In parallel, we are working on a new version of AWAIT trying to prove that the system could be a play for AHM meta-model.

References:

[1] Bailey, C., Hall, W. & Millard, E. (2002). Towards Open Adaptive Hypermedia. In *Proceedings of the Second International Conference on Adaptive Hypermedia and Adaptive Web Based systems*, Malaga Spain. 2002, LNCS 2347, Springer, pp 36-46.

[2] Brusilovsky, P. (2001). Adaptive Hypermedia. *User Modeling and User-Adapted Interaction, Ten Year Anniversary* Issue 11 Alfred Kobsa, ed., pp 87-110.

[3] Murray, T., (1999). Authoring Intelligent Tutoring Systems: An Analysis of the State of the Art. International *Journal of Artificial Intelligence in Education*, Vol. 10, pp. 98-129.

[4] http://www.adlnet.org/scorm/index.cfm

[5] Koper, R. (2004), Modeling units of study from a pedagogical perspective. The pedagogical meta-model behinf EML. Open University of the Netherlands, http://dspace.ou.nl/bitstream/1820/36/1/Pedagogical+metamodel+behind+EMLv2.pdf last visited on May 2007.

[6] Koper, R. & Tattersall, C. (2005) (Eds.) Learning Design: A handbook on modelling and delivering networked education and training. Berlin: Springer-Verlag.

[7] Georgouli K, Paraskakis I. & Guerreiro P., (2003). "A Web-based Tutoring System for Compilers", presented at *the 14th EAEEIE Annual Conference on Innovation in Education for Electrical and Information Engineering*, Poland.

[8] Georgouli K. (2004). WASA: An Intelligent Agent for Web-Based Self-Assessment. In Kinhuk, D. Sampson & P. Isaias (Eds), *Cognition and Exploratory Learning in Digital Age (CELDA 2004)*, Assoc. Editors, L. Rodrigues and P. Barbosa, pp. 43-50.

[9] Economides, A.A. (2005). Personalized feedback in CAT. *WSEAS Transactions on Advances in Engineering Education*, Issue 3, Volume 2, pp. 174-181, July.

[10] Economides, A.A. (2006). Adaptive feedback characteristics in CAT (Computer Adaptive Testing). *International Journal of Instructional Technology & Distance Learning*, Vol. 3, No. 8, August.

[11] Brusilovsky, P. (1999). Adaptive and Intelligent Technologies for Web-based Education. In C. Rollinger, & C. Peylo, *Special Issue on Intelligent Systems and Teleteaching*, Kunstliche Intelligenz, 4, 19-25.