Issues in developing standard-based adaptive learning management systems

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1. Introduction

Current learning management systems (LMS) feature some pending issues. In particular, although we are moving towards a new wave of standard-based LMS, there are few implementations addressing the adaptation problem as a whole. In any case, however, adaptation is bound to be a permanent issue inasmuch as learning is a personalised and adaptive process, which from start to finish should consider individual learner's needs.

An important observation one can make going over the available literature is that there is a gap still present between adaptive learning environments (ALE, on the "research prototype" side) and LMS (on the "commercial application" side). The formers rest on the evolution of three related areas: Intelligent Tutoring Systems, Adaptive Hypermedia Systems and Computer Supported Collaborative Learning (CSCL) systems. The main goal of the adaptive systems is to provide the user with efficient access to the site by first presenting the links and materials that could be of interest, considering the existence of other learners, when available. To solve this problem they apply different forms of user models built up in terms of various user modelling techniques (Kobsa, 2001).

On the other hand, it is worrying to note that most courses on current LMS (WebCT, Blackboard, TopClass, Ingenium, Docent etc.) hardly offer any information about which didactical methods and models they use, nor have been the result of an explicitly representation of them. Moreover, as far as adaptation is concerned, they just offer predefined settings that turn out to be the outcome of extensive customizations.

In order to cope with both issues, a standard-based LMS has been developed and evaluated in the aLFanet project (IST-2001-33288), which main feature is to provide adaptive course delivery based on pervasive use of standards (IMS-LD, IMS-CP, IEEE-LOM, IMS-LIP, IMS-QTI) and several user modelling techniques (that combines knowledge-based methods and machine learning techniques in a multi-agent architecture) (Rosmalen & Boticario, 2005; Santos *et al.,* 2004). The purpose here is not just to facilitate the implementation of courses based on explicit didactical methods (i.e., instructional design, IMS-LD[1]) but also to face the entire life-cycle (i.e., design, administration, use and feedback) as a continuous process which has to be "learner's driven" and, accordingly, based on adaptations. Furthermore, the system has been developed in a flexible and modular way, with multi-agents systems (FIPA) and multi-platform communications (SOAP, XML, WebDav), which facilitates the integration of third parties components, with special emphasis on open source developments that have been already integrated in aLFanet (dotLRN[2], CopperCore[3]).

[1] http://www.imsproject.org/learningdesign/
[2] http://dotlrn.org/
[3] http://www.coppercore.org/

The system has been evaluated at four different pilot sites: “Spanish course for German Learners” (KLETT), “Environment and Electrical Distribution” (EDP), “How to teach through the Internet“ (UNED) and “Communication technology” (OUNL). From this evaluation, with a total number of 111 users (22 KLETT, 28 EDP, 40 UNED, 21 OUNL), and from the very experience of system developers we could come up with some problems in developing standard-based adaptive learning management systems.

2. Adaptation

Firstly, adaptation is a general term that conveys too many features. To clarify the meaning of “active and adaptive learning” from users’ perspective in a general LMS like aLFanet an initial survey among project users showed the main adaptive features to be provided. The inquiry, having in mind the attention to be paid to innovative or latent needs, was based in “focus group” methodology (with experienced users), since the quality and variety of the needs captured was of major importance. The study includes a list of over 100 concrete functionalities to be provided (e.g. The system must allow learners to select the route that better fits their learning style, In the case of wrong answers or failure in the proposed activities, the platform must allow and suggest the learners, the use of alternative learning activities). The general concluding remarks are as follows: *i* Users want to have control over the adaptive features, *ii* The importance given to communication and collaboration between users lead us to think we face a critical success factor (CSF) for supporting these activities with appropriate adaptive tasks, *iii* Learners rely on questionnaires (tests, checklists) for adaptation based on pre-assessment. In particular, learners relate pre-assessment adaptation strongly to their level of knowledge and moderately to their learning styles, and motivation.

On the other hand, from the system viewpoint, we have come up with two intertwine definitions of adaptation in a LMS. First a conceptual definition is as follows:

- *Adaptation is about creating a learner experience that **purposely adjusts** to various **conditions** (personal characteristics, pedagogical knowledge, the learner interactions, the outcome of the actual learning processes) over a period of **time** with the intention to **increase** pre-defined **success criteria** (effectiveness of e-learning: score, time, economical costs, user satisfaction)* (aLFanet, 2004).

In turn, the following operational definition focused on the main features provided by the system:

- *An adaptive system should be capable of: **managing** explicitly defined **learning routes** adapted to each user, **monitoring** the activities of its users; **interpreting** these on the basis of domain-specific models; **inferring user requirements and preferences** out of the interpreted activities, appropriately **representing** those in terms of **user models**; and, finally, **acting** upon the available knowledge on the users and the subject matter at hand, to **dynamically facilitate the learning process**.*

3. Learning cycle

Secondly, building adaptive scenarios is a complicated task which covers the so called “adaptive full life-cycle” of learning. The full life cycle of the learning process is divided in the four following phases (Rosmalen *et al.,* 2004): Design, Publication, Use and Auditing. Adaptation is not an idea that can be plugged in a learning environment, but it influences the full life cycle of the learning process. Thus, in the first place, in order to design an adaptive course, the author can select one or more pedagogical models templates and apply them for the course at hand. Then, in the publication phase, which includes the storage and the management of all data, students (or tutors) get assigned the roles, their group and personal profiles and the rights they have in the course. Afterwards, the use phase provides an adaptive learning environment that includes various features: (1) executes the pedagogical design (LD) as made by the author, (2) monitors the interactions and the results of the interactions of the students, (3) provides recommendations according to LD and users’ interactions, (4) dynamically generates questionnaires that adapt to the

learners evolution in the course. Auditing closes the cycle. It collects data depending on the author's requirements on the actual use of the course and presents them to the author in a clear way (e.g. study hours for a given learner and activity).

4. Adaptation design

Thirdly, another relevant issue is the complexity involved in considering design and runtime adaptations (to cover unpredicted situations). As we have already introduced, adaptation in aLFanet comes from the combination of advanced learning methods specified at design-time, in terms of IMS-LD, and adaptive interaction supported at runtime by user modelling. To facilitate the specification of any learning scenarios it is advisable to use learning design templates (Leshin *et al.,* 1992). In turn, to consider the adaptive functionalities that could come out of the interaction data (i.e., user modelling) in an adaptive LMS, the LD has to be extended with new adaptive features. In particular, we are covering two pedagogical scenarios that cannot be predicted when they arise at design-time: lack of knowledge and high interest level. To help the learner in both settings a Recommender Subsystem launches a recommendation based on user's interactions.

The construction process of an adaptive scenario consists of a sequence of steps with increasing levels of details and possibilities for adaptation. The starting point is to develop the skeleton of the IMS-LD template (e.g., a design template for concept learning) and to perform what we call a *differential analysis* that guarantees the identification of users' characteristics (e.g., level of knowledge, cognitive modality, interest level, preferences, etc.), course features (e.g., learning tasks, learning objectives), users' group characteristics, etc. The second step, called *material analysis*, deals with learning objects and services (e.g., document area, forums, calendar), which are strongly dependent on the course domain and the system level. It includes Learning Objects (LOs) that have specific features that can be used in runtime adaptations, such as "ratings" and "comments", and the relations among them by means of the objectives they address. The third step, called *situated analysis*, introduces the concept of "learner situated in a course context". This is meant to consider extra features from the runtime environment like interaction items (e.g., a particular user's comment on a LO), learning item (e.g., LOs and their relationships), users' interaction events (e.g., messages read through a forum), evaluation items (from QTIs tests), sessions (i.e., a running class), etc.

5. Adaptation evaluation

Finally, coming from the evaluation of an adaptive LMS like aLFanet, we have identified the following usage problems. In particular, both strengths and weak points were detected. As strengths, students mention: 1) dynamic adaptation and recommendations supplied; 2) flexibility of task order; 3) residing on the internet (i.e. all information is available and can be updated and accessed); 4) variety of different exercises and assessments; 5) good guidance and feedback by the use of tests (i.e. interactivity and direct self-assessment of the level of understanding of the course material); 6) course material is adapted at each personal learning profile. Some weak points were identified as well. First, on the design phase: 1) improvement and integration of the authoring tools and 2) more documentation explaining how to implement different adaptive scenarios instead of focusing on the typical use of the tool menus. Second, at use phase were: 1) the effectiveness of the LMS is rated positive. It is possible to reach the learning objectives –depending on the quality of the course contents; 2) the efficiency is rated less positive. The participants suffered performance problems (the system is built up on several independent components, like dotLRN and Coppercore, which are accessible online); 3) the usability and navigation using the current interfaces are seen as weak points. Nevertheless, it is noted that the personalization and the possibility of defining different presentation templates may help to fix these problems. Experiences with the course menus template are rated as more positive.

6. Conclusions

Most current LMS are not focused on providing adaptive course delivery. In fact, there is a gap between research prototypes of adaptive systems and the current use of commercial LMS. In order to integrate both approaches, a standard-based LMS has been developed and evaluated in the aLFanet project (IST-2001-33288), which main feature is to provide adaptive course delivery based on an extensive use of standards (IMS-LD, IMS-CP, IEEE-LOM, IMS-LIP, IMS-QTI) and several user modelling techniques (combines knowledge-based methods and machine learning techniques in a multi-agent architecture).

After the evaluation of the system in various pilot sites and from its own development we have identified some issues in developing standard-based adaptive learning management systems. At first, the very concept of adaptation has to be determined through well defined adaptive features focused on pre-defined success criteria (i.e., improvements to drive the adaptation process) and supported by means of the appropriate system functionalities (that should integrate didactic models with adaptations based on users' interactions).

A central issue is to cover the full life-cycle of learning, which means to consider the different phases of the learning process (i.e., design, administration, use and auditing) as a whole and, consequently, their mutual dependencies. For instance, providing valuable reports to authors, focused on learners' performance (use phase) over pre-defined learning tasks (auditing phase), so that design adjustments can be made (design phase).

To facilitate the construction of adaptive learning scenarios we have defined a sequence of steps with increasing levels of details and possibilities for adaptation, which starts from the well known concept of learning design template.

Finally, end-users have reported strengths and weak points where it is telling to note the difficulties found in developing adaptive learning scenarios (authors) and the high value given to adaptive features (learners).

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