An approach to standard-based Computer Adaptive Testing

Javier Morales, Olga C. Santos and Jesus G. Boticario
aDeNu Research Group, Artificial Intelligence Department, Computer Science School, UNED.
C/Juan del Rosal, 16. 28040 Madrid, Spain
jmoraless230@alumno.uned.es
{ocsantos,jgb}@dia.uned.es
http://adenu.ia.uned.es

Abstract

This paper describes our approach to develop Computer Adaptive Testing functionality for different Learning Management Systems following educational standards and specifications (defined by the IMS Consortium). This functionality can be integrated into standard-based personalized learning routes and is being developed as a Service Oriented Architecture (SOA) to support its generality and applicability.

1. Introduction

Nowadays, learning management systems (LMS) should not only offer online information and communication channels, but also be able to guide the student’s interaction to educational goals clearly specified [8]. To that end they have to offer some kind of adaption to the student’s learning process.

There are several challenges for providing standard-based adaptation processes in LMS and among them, evaluation testing represents an interesting alternative.

Evaluation tests are used in every learning process to infer the student’s knowledge based on some evidence obtained from the student’s behavior. They are very relevant, since they allow teachers to determine if the student has assimilated the content introduced during the learning process. Evaluation tests can be used to offer adaptive functionality within the learning process as described in [4].

Computer-Adaptive Testing (CAT) [1] is the way to offer questionnaires that adapt to the student’s ability level. In order to improve the efficiency of the learning process, CAT systems select items dynamically according to the student knowledge and preferences.

One of the most common approaches to CAT is called Item Response Theory (IRT) [2], a methodology for selecting optimal items on the basis of information rather than difficulty. IRT assumes that the answer to a question depends on the knowledge of the subject.

In this paper we present some adaptive testing developments based on standards and specifications, and the approach to improve learning effectiveness. In sections 2 and 3 we describe the related work and the research developments on adaptive education. Then in section 4 we describe technically our new development. In section 5 we explain the evaluation plan and finally, we include some conclusions and future work.

2. Related works

The main difference between CATs and the traditional Paper and Pencil Tests (PPTs) is the capability to adapt to the individual student.

CAT systems have a main advantage over PPTs, which is the significant decrease in test length. CAT systems do not need to include questions of all levels of difficulty, in order to discriminate all different knowledge levels. Adaptive tests maintain a higher level of precision than PPTs and students receive different sets of items, depending on the item selection algorithm, rather than the same set of questions for all. Because CAT systems are computer-based, adaptive tests can show the results immediately after finishing. All these advantages translate into time saving for students (and teachers).

The research on Adaptive Testing has grown considerably in the last years as shown in [4]. In [3] SIETTE is described, one of the first and most completed web-based tools for adaptive testing. It is developed using Java applets and is based on the Item Response Theory (IRT). [5] describes a system that uses CAT to estimate the level of proficiency in English for those students whose mother tongue is not English. Our research work supports IRT approach.
following IMS Selection and Ordering Specification (IMS-QTI S&O).

We refer to standard-based CAT as the development of Computer Adaptive Testing functionality following educational standards and specifications which enable a lot of advantages such as the reusability and interoperability of the learning materials.

3. Background

Over the last years, research work follows the approach that adaptive functionality has to be supported at design time, publishing time and runtime by LMS. In this line the integration between learning processes, evaluation tests and adaptive testing represents an interesting alternative to support adaptation to the student interaction flows.

In the field of aLFanet (IST-2001-33288) and ADAPTAPlan (TIN2005-08945-C06-01) projects, the aDeNu research group has been researching the best way to improve the effectiveness of the learning process by providing adapted responses to the students’ needs in LMSs. Related to this, a dynamic modeling functionality has been developed [7], building an architecture that provides intelligent personalization capabilities to individual learners’ preferences, habits, interests and needs through three different areas (adaptation by instructional design, interaction and presentation). At design time, the IMS-LD authoring tool allows authors to generate personalized course flows based on IMS Learning Design (IMS-LD) specification. At run time, the contents and questionnaires are presented to the user adapted to his/her needs and context.

We are applying this approach to the well-known open source standard-based LMS called dotLRN, which supports both IMS-LD and IMS Question and Test Interoperability (IMS-QTI) specifications. We have already developed the integration between IMS-LD learning processes and IMS-QTI evaluation tests to fully provide adaptive functionality [6]. Now, we are working on extending dotLRN to support Adaptive Testing functionality following IMS-QTI S&O.

4. Personalized learning routes in a standard-based open architecture

aLFanet architecture was developed at the time that no LMS supported adaptation and educational standards. dotLRN LMS supports currently IMS-LD instructional design adaptation integrating with IMS-QTI questionnaires. However, it does not provide adaptive testing and we are working on extending dotLRN to support IMS-QTI S&O specification.

Our goal is to offer this functionality in an interoperable way. Thus, we are designing a framework for adaptive testing based on a Service Oriented Architecture and IMS Specifications which consists of the following steps:

- **1.** Creation of the bank of items (IMS-QTI Authoring tool)
- **2.** Packaged IMS-QTI items (IMS-CP packaging tool)
- **3.** Metadata added to the packaged items (IMS-MD authoring tool)
- **4.** Definition of Selection and Ordering rules to the metadata packaged items (IMS-QTI S&O authoring tool) which can point to IMS-LD properties
- **5.** XML describing how to dynamically build the questionnaire

The resulting output is an XML file describing the IMS-QTI S&O rules and the items characterized with metadata, which can be integrated as a resource in an IMS-LD course. These metadata refer to the knowledge level assessed by each of the IMS-QTI items and is to be mapped against the user attributes that store the progress achieved by the student. When a certain questionnaire has to be offered to the user at a certain point in the learning process (due to the current user features and the context at hand), the questions in the questionnaire are also adapted to the particular user. Thus, different questionnaires are offered to different users.

This framework is being applied to dotLRN reusing some components developed for aLFanet, such as the IMS-QTI authoring tool and player implemented by Software AG. In particular, we are working on integrating these components into dotLRN via web services.

To define personalized learning routes, the author has to specify at design time the main goals and objectives of a learning course in terms of competencies. He/She creates a repository of resources defining theoretical lessons, examples, exercises, assessments, etc. Then, the author characterizes them using IMS-MD and classifies them according to their learning objectives. With this information, the rules can be defined. For instance, a questionnaire with 2 questions addressing the objective LObDise (Design), from module 3, purpose preKNW (preknowledge) and for students with deductive learning style:
In the runtime phase, the system analyses the available student skills (IMS-LIP) and the course’s repository. Then, the system works on how to achieve a student’s goal generating the learning process as an IMS-LD unit of learning (UoL). The system filters the learning objects with the learning objective and selects the best one for the student. Finally, the system provides adaptive learning flows where the evaluation of each UoL is an essential step to guide the process. Every IMS-QTI item is associated to a specific concept and knowledge level through its metadata. The system selects the appropriate items to build an adapted questionnaire to the learner. Once completed by the learner, the evaluation process updates the knowledge properties in the user model, which are used in the conditional of the IMS-LD UoL.

5. Evaluation approach

To check the impact of adaptation testing in the effectiveness of student’s learning we are defining an Evaluation Plan in the context of A2UN@ project. To evaluate the adaptive functionality developed for dotLRN LMS presented in [6] we are redefining some learning processes according to IMS-LD specification. Particularly, we are carrying out an online course called “Learning to teach through the Internet” from January to June 2009 on dotLRN instance at aDeNu. There are ten students enrolled on it and they will learn different modules (IMS-LD) with evaluation tests inside. Some evaluation tests will not adapt to the student’s preferences and some will carry out adaptation. With the final results, we will be able to analyse the modelling methods used and the impact of computer adaptive testing in the student’s learning process as described in [9].

6. Conclusions

In this article we presented the work done in the last years by aDeNu research group with the objective of supporting Adaptive Testing functionality following relevant educational standards and specifications. This is being done by the development of new adaptive features for dotLRN open source LMS.

Our approach provides personalized learning routes integrating learning processes, evaluation tests and adaptive testing and supporting relevant educational specifications.

Acknowledgments

Authors would like to thank the Spanish government for funding ADAPTAPlan (TIN 2005-08945-C06-00) and A2UN@ (TIN2008-06862-C04-01/TSI) projects.

References


