The Potential for Open Learner Models in Adaptive Virtual Learning Environments

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Abstract. This paper presents the initial design of an Open Learner Model for an Adaptive Virtual Learning Environment (SAVEMA, The Spanish acronyms of Adaptive Educational Virtual System with Open Model), with the aim of helping learners to reflect on their knowledge, and to support their self-directed use of a Virtual Learning Environment.

Keywords. Adaptive virtual learning environments, open learner models

Introduction

In the context of virtual and blended education, several functionalities have been proposed for Learning Management Systems (LMS): intelligent LMS (iLMS) based on standards in aLFanet [1]; integration of the LMS Moodle (Modular Object-Oriented Dynamic Learning Environment) and the adaptive hypermedia system (AHS) APeLS (Adaptive Personalized eLearning Service) [2]; recommending service integrated into the OpenACS/dotLRN framework via Web services in ALPE, EU4ALL, ADAPTAPlan [3]; an adaptive virtual learning environment based on an Integral user model [4]. Each of these works add adaptive characteristics to an existing LMS through learner models. However, in these approaches the learner does not have access to their learner model.

Learning management systems or courseware management systems offer a wide variety of functionalities, such as integrating instructional material, e-mail, chat sessions, online discussions, forums, assignments, etc. Recently some environments have been extended to support standards and specifications in E-learning [5, 6]. Although these characteristics make this kind of system more versatile, and extensions give them the potential for adaptive characteristics, even the most advanced LMS systems tend to be used similarly to more traditional computer-assisted instruction support.

On the other hand, many educational research projects have built systems which may have lost some of the versatility, but gained characteristics such as: adaptive behavior [7; 8; 9]; support for collaborative learning [10; 11] and promoting reflection [12; 13; 14], encouraging learner independence and responsibility [15], improving accuracy of the learner model [13; 14]; helping learners to plan and/or monitor their learning [13; 14] and affording learners greater control over their learning [16] through an Open Learner Model (OLM), among others. Although their use is generally more restricted than LMS (for example, to a specific domain, or in specific research studies),

these approaches have shown some positive results, specifically system which have open the learner model to the students in the educational area.

In [17] Adaptive Virtual Learning Environment named SAVE (the Spanish acronyms of Adaptive Educational Virtual System) has been proposed. SAVE use the LMS dotLRN which, besides be open source, has been suggested as useful for reusability, accessibility [18] and usability [19]. The dotLRN platform was extended with adaptive characteristics based on the competence levels of each learner. To carry out the adaptive behavior, a unit of learning (UoL) has been designed with the IMS learning design specification [IMS-LD]. During the design phase, the instructor defines some variables which are used to set the competence level of the student. The competence level is inferred by a multi-agent system (MAS) based on the questions answered by the learner in tests with IMS questions and test interoperability [IMS-QTI]. The adaptive behavior is then obtained through the different paths previously defined in the UoL. (Further details can be found in [4]).

To improve SAVE an Open Learner Model is proposed, this new proposed system is named SAVEMA (the Spanish acronyms of Adaptive Educational Virtual with Open Model). This paper focuses on the potential for opening the learner model in AVLEs and the design of an OLM in SAVE.

The paper is organized as follow: In section 1 the Open Learner Model (OLM) and relations with Adaptive Virtual Environment (AVLE) are introduced. In section 2 details about the learner model and adaptive characteristics of the Unit of Learning (UoL)/course are presented. In section 3 initial design of SAVEMA is proposed. Finally, the summary is presented.

1. The Potential for Using an OLM in an Adaptive VLE

Open Learner Models (OLM) are learner models that can be accessed by the user, in full or in part, and have been used for a variety of purposes, e.g. improving accuracy of the learner model; promoting learner reflection; helping learners to plan and/or monitor their learning; and affording learners greater control over their learning [20].

At this stage of our work we focus on promoting learner reflection on their competence level, as an important element to facilitate meta-cognitive behavior, in accordance with suggestions that students who engage at a meta-cognitive level tend to achieve significantly higher learning results [21]. In [22] reflection is defined as “a generic term for those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to a new understanding and appreciation”. There is evidence to suggest that effectiveness in the learning process could be enhanced when a student reflects about their own knowledge [22; 23; 24]. Along the same lines, it has been argued that OLMs have the potential to foster reflection and meta-cognitive skills, as the system provides the user with a representation of their understanding of a subject as a starting point [15]. Learning gains have indeed been demonstrated in some instances, using a simple OLM presentation [25; 26].

As adaptive capabilities are added to a traditional VLE, learner model is available to open to the user. The considerations and characteristics of this OLM are presented below.

2. Learner Model and Adaptive Courses in SAVEMA

In this section general details about the learner model and adaptive characteristics of the course are presented. The open learner model design in SAVEMA is presented in the next section.

2.1. Learner Model

The learner model of the VLE is presented in accordance with the three layers identified for the analysis of user models by Brusilovsky and Millan in [27]: what is being modeled (nature), how this information is represented (structure) and how different kinds of models are maintained (user modeling approaches).

The information represented in our learner model relates to competences; although there are similarities with knowledge representation, the differences can be found in the conception and the implications that these have for the learning process. The competences are structured in a taxonomy (e.g. for a career, high school program), defined with the IMS Reusable Definition of Competency or Educational Objective [28] specification, and implemented as shown in figure 1.

As an overlay approach has been used [28], the implementation takes into account the UoL structure used to build the domain model. The learner model is maintained through a multi-agent system which builds and updates the learner model overlaying the domain model with the competence level obtained by the student after answering questions in the respective UoL [4].

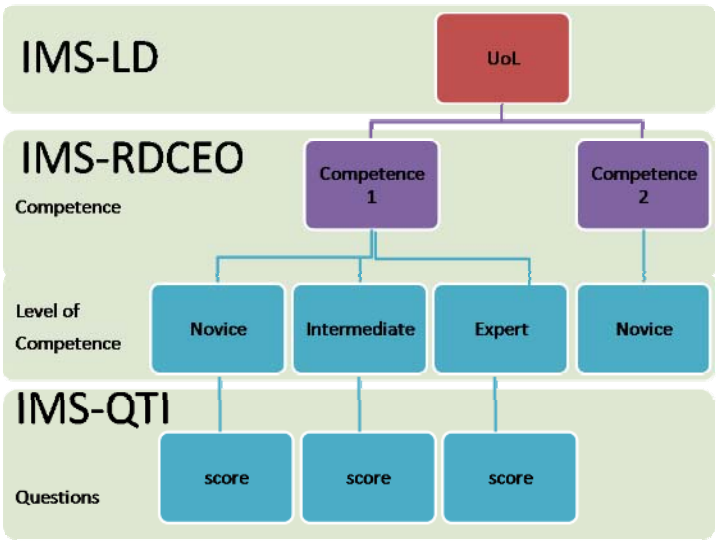

Figure 1. Structure of the learner and domain model.

In figure 1, each division shows the specification used and the relations defined between them. The structure of the domain model is based on components identified in a competence proposed by Tobón in [29]. Tobón proposes a model which considers tree elements in a competence: problems that the competence address to solve, description of the competence which summarizes the main idea of the competence and

their context and criteria for evaluate if a competence is achieved or not. Besides, Bloom taxonomy [30] has been used to classify development criteria in a competence [31] (see table 1), and also for question classification. In table 1, competence levels are defined: novice, intermediate and expert.

Table 1. Level of competence based on Bloom's taxonomy

BLOOM OBJECTIVE	DESCRIPTION (COGNITIVE DOMAIN)	LEVEL
Knowledge	Remembers a fact without a real understanding of the meaning	Novice
Understanding	Gets the meaning of the material	
Application	Can use the learned material in new and specific situations	Intermediate
Analysis	Can divide a complex problem into different parts	
Synthesis	Can join different parts in order to create new entities	
Evaluation	Can judge values of a subject with a specific propose	Expert

2.2. Adaptive Course

The adaptive course was designed for students in the Universidad Pontificia Bolivariana in Colombia as a part of an introductory computing course for informatics students. The course includes the topic Object Oriented Programming (OOP), which has been used as the main topic for the design of the virtual course. Many of the resources used for course generation were taken from SHABOO [32], and other resources were provided by the course instructor. The course includes three parts: Introduction, Objects and Class, and was built using the authoring tool "Reload Learning Design Editor" and IMS-LD [33] specification.

The designer defines the level and number of competence(s) that could be achieved in a course by a learner. In the Unit of Learning/course used two competences were defined. The first competence could be achieved until novice level and the second one could be achieved until intermediate level. Rules for adaptive behavior in accordance with the competence level of each student were defined in the IMS-LD. These rules take into account the values of each variable for carrying out the adaptation. However, these variables need to be updated during run time. On completion of the design phase, the UoL was uploaded to the dotLRN VLE and a run was created with the package ims-ld for the Unit of Learning/course available for the students. Because the variables in the package ims-ld in dotLRN need to be updated manually, we have integrated it with a multi-agent system which performs this task (additional detail can be found in [4]).

The Unid of Learning was loaded in the dotLRN platform that runs on a server in UPB [34]. On this platform a class named Object Oriented Programming was created; in which students have different services such as forums, chat, space to store and share files, calendar, news, questionnaires, units of learning, among others. In the link to units of learning, students can choose the UoL available to them.

The course was available for one month, and two tests were administered, in the middle and at the end of the course for evaluate the student competence in the course.

The questions were designed mostly in SHABOO [32] and characterized with the IMS-QTI [35] specification in the package Assessment in dotLRN. Each question is identified with an id that allows the competence, the level and the performance criterion that it assesses, to be tracked. A low average was obtained by the students in the two tests. (The averages for the two tests are based on a scale from 0 to 5, and were 3.49 and 2.77 respectively.) We therefore aim to increase user engagement as has previously been found to occur with the introduction of a simple OLM [36], in an AVLE context.

3. SAVEMA in the SMILI☺ OLM Framework

The SMILI☺ OLM framework [20] is designed to help researchers to focus on the main considerations for opening a learner model. These considerations have been used in this section to present the description of our OLM. The framework include an overall view in the OLM design which help to the designer focus on the main considerations for open a learner model. The framework take into account the purpose, what is modeled, how is the model presented and who controls de access to the model. Furthermore some additional aspects are considered in each one of these considerations, (see tables 2 to 5).

Table 2. Purpose of Open Learner Modelling.

Purpose	*Accuracy*	*Reflection*	*Plan / Monitor*	*Collab / Competition*	*Navigation*	*Right of access, control, trust*	*Assessment*
SAVEMA		XX					

In the table No. 2 the upper part shows the general issues. The lower part shows the goals of openness of the learner model: XX for central goals; X for lesser goals and x for minor concerns. There are many purpose for open a learner model, however in this work the reflection purpose have been chosen as a way of promote meta-cognitive state that encourage the autonomy and responsibility in the learning process.

Table 3. WHAT is modeled?

Elements / Purpose	Properties	*Reflection*
1. Extent of model accesible	Complete	

	Partial	X
2. Match underlying representation	Competence level Knowledge Difficulties Misconceptions	X
3. Access to uncertainty	Learning issues Preferences Other Other users' LM	
4. Role of time	Previous Current Future	X X
5. Access to sources of input	Complete Partial	 X
	System Self Peer Instructor Other	X
6. Access to model effect on personalization	Complete Partial	

In the table 3 what is modeled is summary. The main aspects considered are that the open learner model shows the competence level which take into account the current and previously level achieved. Only the system has access to the sources input and the learner model is showed in a partial way because there is some additional information in the learner model that at this time is not opened.

Table 4. HOW is the model presented?

Elements / Purpose	Properties	*Reflection*
7. Presentation	Textual (i.e...) Graphical (i.e...)	 X (level, skill meter and colours)
	Overview Targeted/all Details All Details	 X
8. Access method	Inspectable Editable Addition Student persuade System encourage Negotiated	X
9. Flexibility of access	Complete Partial	

In the table 4 the way as the model is presented is described. The learner model is presented in a skill meter way with some colors that help to identify levels and competences. Not all details are available at this design in the leaner model. There are different methods for do that presentation of the model. The inspectable method has

been chosen in the presentation of the learner model in SAVEMA, this means that the student can view their learner model.

Table 5. WHO controls access to the model?

Elements / Purpose	Properties	*Reflection*
10. Access initiative comes from	System User Peer Instructor Other	X
11. Control over accessibility (to others)	Complete Partial	
	System Peer Instructor Other	X

Finally in the table 5 details about who control the access to the models is given. In the design of this OLM the user access are defined but the student cannot decide what is available to see.

In figure 2 the OLM is presented. On the left side, the competence levels novice, intermediate and expert are shown using the colors yellow, blue and green, respectively. Others visual effects are added to facilitate their differentiations. On the right hand side, a skill meter is used for each competence at a specific level. Skill meters were chosen as they are one of the most common forms of simple OLM adopted in systems [e.g. 25; 37; 38], and have enjoyed high levels of use in real (voluntary) use settings to support university courses [36; 39].

As we have said, in the Unid of Learning/course design a competence could have until tree levels: Novice, Intemediate and Expert. The number of levels depends of the scope that the designer consider achievable. Because the designer of the course used has considered only two levels, figure 2 does not show any criterion in the expert level. The first competence has two criteria and the second one has one criterion. The skill meter shows how much the learner has achieved in a specific level for a specific competence.

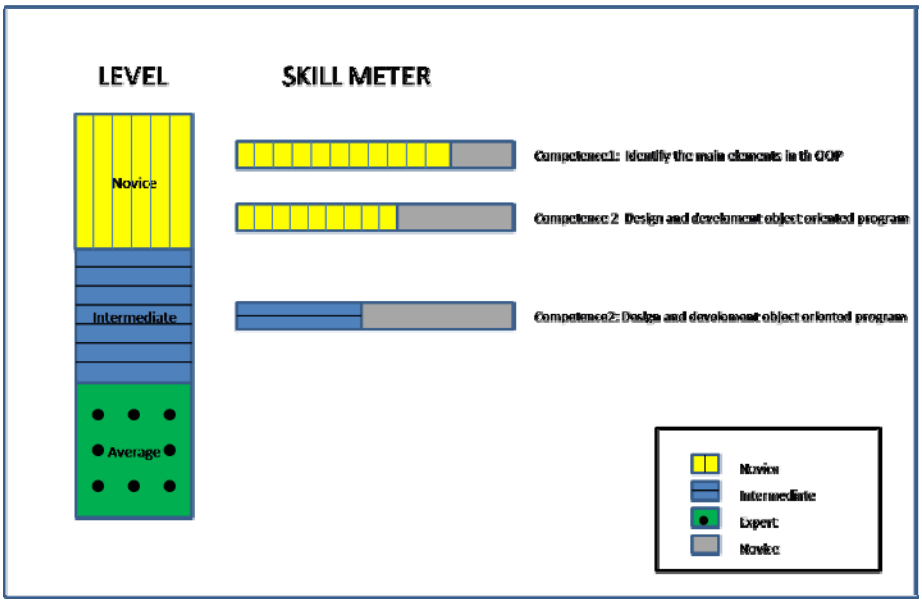

Figure 2. Open Learner Model representation in SAVEMA.

4. Summary

SAVEMA was created with the purpose of achieving reflection in the context of an adaptive VLE. The OLM represents competence level: novice, intermediate and expert, which have been defined based on Bloom's taxonomy [30]. The presentation of the learner model is done through the use of levels, skill meters and colors, and the method of access to the learner model is 'inspectable' – i.e. the learner can view their learner model, but may not directly contribute information about their knowledge. Although some preliminary studies have been done for validate SAVEMA this paper focus on the design of OLM. Future work will deploy new designs of OLM and also other studies to investigate the extent to which a OLM may facilitate use of a VLE; and investigate whether students might also benefit from an OLM using other features described in the SMILI☺ Framework, in the AVLE context.

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