6

# An Approach in Personalisation and Privacy in E-Learning Systems

Itana Stiubiener,Wilson Vicente Ruggiero and Marta Rosatelli
*Universidade Federal do ABC and Universidade de São Paulo*
*Brazil*

## 1. Introduction

The development of user-adaptive or personalised systems has had a great impact on recent developments of application areas such as: information filtering, recommendation systems for products and services, e-commerce, help systems, support systems for on-line collaboration, accomplishment of routine tasks, interface agents, and so on. The approaches of user-adaptation or personalised systems are particularly promising to supply the demands of teachers and to adapt to students in the e-learning context.

This chapter presents an approach to personalisation in e-learning. Applied in the context of a Learning Management System (LMS), the aim is to make a LMS more flexible, adaptable, and extensive to a broad and diverse group of users. An adaptive mechanism dynamically provides didactic contents and learning activities that match the pedagogical goals with the student's preferences and skills.

To accomplish this, the concept of a Personalised Learning Policy (PLP) is introduced. This policy allows instructional designers to configure the system. It is based on the student's profile, which considers both the observation of the student/system interaction, and the aspects that the teacher judges relevant to be observed. These aspects are implemented in the system through a data structure named Orientation Layer. The Orientation Layer is a data model that represents the student's preferences and skills. As a result, the LMS is endowed with a level of configurability and the system adaptive behaviour is consistent with the system users (i.e. teachers and students).

It is important to note that in order to enable the personalisation according to the approach presented in this chapter a LMS should be compliant with the Sharable Content Object Reference Model (SCORM) (ADL, 2009) and have a Run-Time Environment (RTE) that can provide information about learning events in real time.

The remainder of the chapter is organized as follows. Section 2 overviews the student profile. Section 3 describes the PLP. Section 4 illustrates the application of the concepts of a PLP. Section 5 presents a discussion about Privacy versus Personalisation. Section 6 reports on related work. Finally, section 7 presents the conclusions and directions for further work.

## 2. Student Profile

Individuals present distinct ways of learning, different backgrounds, and diverse preferences. By composing these characteristics, aspects of the student learning process and knowledge construction process can be inferred by a computational system and registered in a profile. In this work, a Learner Profile (LPROF) aims to represent a set of characteristics associated to a student.

Although a number of algorithms and models aim to handle (aspects of) this issue, each of them tackle one or other aspect that is related to modelling the user, such as:

- How to deal with the uncertainty of an approximate profile,
- How to estimate a user profile with a significant number of observations,
- What is a significant number of observations,
- What is a significant observation, and
- How to adapt an algorithm to changes in the users' characteristics along a time period.

The representation of LPROF is a value expressed by a set of characteristics that takes into account aspects of the student's behaviour observed by the system after an event (or a programmed sequence of interaction events) between the student and the system. This set of characteristics has distinct variable values during a time period:

$characteristic_{1,m1}=\{c_{11}, c_{12}, ..., c_{1m1}\}$,
$characteristic_{2,m2}=\{c_{21}, c_{22},..., c_{2m2}\}$,
...
$characteristic =\{c_{n1}, c_{n2}, ..., c_{nm}\}$ ,where m, n vary from 1 to N

LPROF is represented as a commutative Modoid:
$(A, S, \varepsilon, \|)$,
where A is the set of observable behaviour characteristics of an individual in a e-learning system. Examples of these are student's learning motivation, autonomy, media preference, pedagogical preference, and so on.
S is the set of all possible A characteristics sequences,
$\varepsilon \in S$, is the empty sequence,
$\| : S \times S \rightarrow S$ (1)

The binary operation in (1) establishes the student static profile, represented by the concatenation of the behaviour characteristics that compose the LPROF and satisfy the following:
$f: N \rightarrow S$
is the dynamic profile, that can vary along the time with the following properties:
$\forall\ \sigma \in S : \varepsilon \| \sigma = \sigma \| \varepsilon = \sigma$,
$\forall\ \alpha, \beta, \gamma \in S : (\alpha \| \beta) \| \gamma = \alpha \| (\beta \| \gamma)$ ,
$f(0) = \varepsilon$ , in instant $t = 0$.
Along a time frame, the student interaction events take place and, according to these events, new characteristics can be added to the student's LPROF:
$f(t+1) = f(t)$, maintain the profile value (i.e. non relevant event),
$f(t+1) = f(t) \| ci$, concatenate a new characteristic in the profile (i.e. relevant event),
$f(t+1) = \varepsilon$, restart the profile estimate, (i.e. event determines a profile update).

In order to estimate a LPROF, didactic contents and learning activities must be planned in a way to enable programming strategic checkpoints in the sequence of learning activities and student's choices, which are translated into interaction events to be observed.

## 3. Personalised Learning Policy

Adaptive systems (Kobsa, 1996, Kobsa, 2001) include a user model that represents student's knowledge, objectives, interests, and other characteristics that enables a system to differentiate among its users. The system gathers information, models users, and uses this information to provide adaptation. This enables the system to interact with several users, in the same context, but in different ways. The sources of information on which the adaptation is based might range from a user's interaction to a direct request for information.

An important aspect of Information Systems and Adaptive Systems is that their development process is a very onerous activity and, depending on its complexity, a lot of time is required and great costs are involved. In this sense, it is desirable that Adaptive Systems present, as much as possible, a degree of configurability, making them extensible, capable of being applied in distinct contexts, and adaptable to new demands. In spite of the difficulties in implementation issues, and considering that not all aspects of a system can be configurable, those that can be implemented and configured should provide for freedom and versatility in the system's use.

System configuration can be associated to adaptation techniques since both of them aim to provide for specific needs of users, adapting some of system functionalities to these needs and yet maintaining the system's organization unchangeable. Particularly in e-learning systems, the possibility of configuring the criteria for observing student's interactions and procedures to be executed in response to these introduces a degree of freedom, as the configuration determines which conditions will trigger system adaptation. Thus, teachers and instructional designers can emphasize different aspects of didactic contents and learning activities and focus on different student's characteristics, cognitive aspects, and pedagogical approaches, among others.

The PLP is implemented by a configurable set of rules and procedures that define the adaptation of didactic contents and learning activities in an e-learning environment. This novel concept implies more degrees of freedom in the personalisation process, and the adaptation is made in an open and flexible way (i.e. not using a rigid set of adaptive criteria).

The rules defined in a PLP establish conditions associated to events that can take place during a given learning experience. Such events can be related to an observable characteristic of a student that belongs to his/her LPROF. Thus, from the observation and interpretation of the student's interactions, the system estimates the LPROF at a given moment and associates it to the pre-defined conditions. The policy also defines the procedures that should be executed to adapt the system's actions. A condition included in a policy might refer to the student's current interaction (i.e. interaction event) and/or previous interactions registered by the system.

It is worth noticing that not all student's interactions are relevant to the LPROF's estimation. When configuring the PLP, it is necessary to define relevant interactions and to which state in navigation model these are associated.

### 3.1. System Organization

Traditional e-learning systems (i.e. that do not personalise or adapt) are organised as in Figure 1. The exchange of information and/or data between the system components are carried out as described below (numbers correspond to arrows labels in Figure 1)

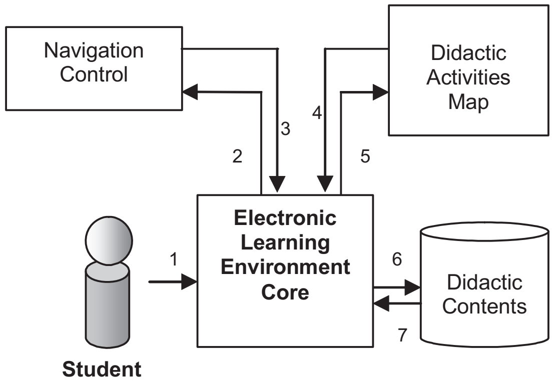


Fig. 1. E-learning system typical architecture

1. student performs action,
2. requests the student's status in the navigation map,
3. returns student's navigation status,
4. requests the next didactic content or learning activity according to student's status,
5. returns the indication of next didactic content or learning activity,
6. requests the didactic content or learning activity ,
7. returns the didactic content or learning activity ,
8. presents the didactic content or learning activity.

Aiming to personalise the interaction in e-learning systems, there are two important interaction events that should be observed: (1) those that request a new didactic content or learning activity and (2) those that are relevant to estimate the LPROF. In this case, the management of learning activities demands information related to such events, for instance, information provided by the RTE defined by the SCORM standard (Dolog & Nejdl, 2003).

In other words, it is important to enable the e-learning system to handle students' interaction and also to provide information about this interaction. This makes possible to analyse and react to the information as defined in the PLP. Three types of events can take place in this context. The first type of event (Type 1) triggers the LPROF updating. The interaction event(s) and the PLP navigation rules are the input for the updating process. The second type of event (Type 2) triggers the adaptation process, which determines the next didactic content or learning activity to be presented to the student according to his/her LPROF. There might also be irrelevant events (Type 3) that do not change LPROF and therefore there is no need for adaptation.

Three types of rules should be defined and configured in a PLP:

- Navigation rules: define which student's actions are relevant to be observed and stored by the system to compose and estimate the LPROF;
- Adaptation rules: define the system next action, e.g., the didactic content and/or learning activities that will be presented next;
- LPROF's estimation rules: define the conditions to initialise and/or update a profile. An example of a rule is: "If a student presents characteristic X associated with 40% of his/her significant interactions then his/her LPROF equals A". As not all interactions are important and significant to initialise and/or update a LPROF, the number of observations is not static and thus this variable should also be defined in the PLP.

All interaction events are observed by the system. However, the events considered relevant to initialise and/or update a LPROF or to present new didactic contents and learning activity are defined in the policy. A PLP can be planned for a specific set of didactic contents and learning activities according to the pedagogical strategies. Therefore, the organization and conceptual model allows configuring, at the same time, different policies applied to different students and using the same didactic contents and learning activities.

The representation of a PLP takes into account: Interaction, Status, Condition, Action, and the LPROF.

Interaction represents a student's interaction action at a certain moment, e.g. clicking on a checkbox for making a choice, entering a URL on a browser, and so on.

Status represents the student's state in the navigation model. Any interaction carried out by a student is associated to a state in the student's navigation model. Every time the student makes an action that is associated to a relevant event, it causes a transition in the navigation model. Depending on the event, the system executes an action according to what is defined the policy.

Condition relates to what is verified by the system and that determines a LPROF update and/or presentation of a new didactic content or learning activity.

A configurable structure named "Orientation Layer" determines the selection of the criteria used in the adaptation process. Each layer represents an aspect to be observed, i.e. a dimension of observation according to what is deemed as relevant. The Orientation Layers constitute a data model, which is configurable and reusable. The configuration feature of the Orientation Layer structure facilitates the introduction of a new approach or direction for the student observation. This is an important characteristic as it facilitates the adoption of the system by professionals from different knowledge areas. In many situations we observe that different teachers and instructional designers can adopt diverse pedagogical strategies. For instance, at the same time a teacher or instructional designer can adopt strategies to stimulate and improve a student unique cognitive characteristic, another teacher or instructional designer might prefer to stimulate an alternative characteristic with the objective of improving a different ability of the same student.

The number of layers, characteristics considered, and options available are defined by the teacher or instructional designer. Table 1 shows an example of a possible configuration of the Orientation Layer structure.

Once the LPROF is initialised or updated according to the observation of the characteristics defined in the Orientation Layers structure, the system is ready to adapt the didactic contents or learning activities by executing rules and actions defined in the PLP. As the system register a student interaction, the LPROF Manager module verifies which characteristic of an orientation layer is associated to a condition in the policy adaptation rules and, depending on this association, estimates (i.e. initialises or updates) the current LPROF. The steps and activities that should be carried out to configure a system according to the approach presented in this chapter are shown in Figure 2.

| | |
|---|---|
| Screen layout | Presentation format |
| Texts, Video, Audio, 2D animation 3D animation, etc. | Media format |
| | Level of knowledge |
| | Psychological model |
| | Learning style |
| | Pedagogical model |
| | … |
| | Observation of Multiple Intelligences [ Gardner,2003] |

Table 1. Example of an Orientation Layer structure

**3.2. State Transitions**

The actions and associated interaction events in a PLP are represented by a Finite State Machine. A tool interprets the rules defined in a policy and transforms them by translating the policy states and actions into a transition table. The system then is able to interpret and execute the actions.

## 4. Use scenario

The application of the PLP concept is illustrated with an example of an Orientation Layer with two layers and a set of rules.

The first layer - Learning Orientation - is based on the Learning Orientations model (Martinez & Bunderson, 2000; Martinez, 2002), which takes into account emotions and affective aspects, self-directed and committed learning effort, and learning autonomy. It allows understanding and matching learning orientations, fostering self-motivation, encouraging online relationships, and supporting successful learning and performance. It distinguishes four different learner profiles: Transforming; Performer; Conforming; and Resistant. The second layer - Media - refers to the type of media that the student prefers for presentation of didactic contents and learning activities. These two layers might be applied to a LPROF as exemplified by the rules below:

LPROF = Video_Preference if student chooses a video explanation in more than 33% of relevant interactions.

LPROF = Transforming_Learner if the student prefers case studies in 40% of relevant interactions.

Updating, Navigation, and Adaptation rules are:

**Updating**: **If** student chooses video in 33% or more of relevant interactions **then** LPROF = Video_Preference.

**Navigation**: **If** student chooses a case study in a relevant interaction **then** increment the Transforming_Learner counter.

**Adaptation**: **If** ((LPROF=Video_Preference) and (LPROF=Transforming_Learner)) **then** ((present a video) and (present a case study)).

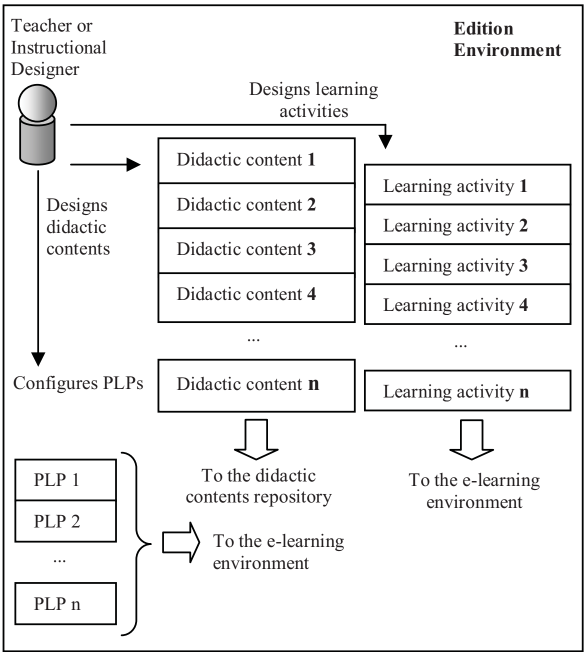


Fig. 2. Edition environment and configuration of an e-learning environment that uses a PLP

## 5. Privacy versus Personalisation

As Web based Systems are improving in the sense of offering personalised services, users privacy have to be considered and some questions must be answered: are we sure that all users want personalisation and also, are we sure that all users know exactly which are the implications of personalisation? Specially in educational systems developers of personalised systems must be aware that observing a student can have disagreeable and undesirable consequences.

Kobsa (2007) presents a discussion and some considerations about privacy that strive to approximate personalisation techniques to privacy rules. In his research three groups of users, characterized by the privacy characteristic, are presented:

1. privacy fundamentalists: extremely concerned about the possibility of the use of their data, even if privacy mechanisms are present,
2. privacy unconcerned: expresses a mild concern about privacy, and
3. privacy pragmatics: concerned about privacy but much less than privacy fundamentalists (Kobsa, 2007).

Kobsa suggests that in personalised systems developers must communicate the benefits of personalised services to the users not only for a legal reason (privacy laws) but also because

if users know the benefits of these services they probably will be more motivated to collaborate with information and any other action required (Kobsa,2007).
In the model presented in this chapter if one wants to consider the privacy characteristics presented by Kobsa it is not required to reprogram the system software. It is just necessary to introduce these characteristics as a new variable to be observed and considered in the PLP. Considering the set of rules presented in Section 4:

LPROF = Video Preference if student chooses a video explanation in more than 33% of relevant interactions.
LPROF = Transforming Learner if the student prefers case studies in 40% of relevant interactions.

Updating, Navigation, and Adaptation rules are:

**Updating**: If student defines him/herself as a **privacy fundamentalist** then do not personalise any activity and **LPROF = Does Not Want Personalisation**

**If student defines him/herself as a privacy unconcerned** then

**Updating**: **If** student chooses video in **50%** or more of relevant interactions **then** LPROF = Video_Preference.
**Navigation**: **If** student chooses a case study in a relevant interaction **then** increment the Transforming_Learner counter.
**Adaptation**: **If** ((LPROF=Video_Preference) and (LPROF=Transforming_Learner)) **then** ((present a video) and (present a case study)).

**If student defined himsef/herself as a privacy** pragmatics **then**

**Updating**: **If** student chooses video in **33%** or more of relevant interactions **then** LPROF Video_Preference.
**Navigation**: **If** student chooses a case study in a relevant interaction **then** increment the Transforming_Learner counter.
**Adaptation**: **If** ((LPROF=Video_Preference) and (LPROF=Transforming_Learner)) **then** ((present a video) and (present a case study)).

Notice that a different number of observations are programmed to estimate a LPROF according to the privacy student's characteristic.
It is easy to observe that when users want to consider any new variable in the personalisation process presented in this chapter, there is no need to change system's code but only to reprogram PLP´s rules.
In the example presented in Section 4, three new rules were introduce to estimate his/her LPROF. The configuration of new rules can cause some overhead, sometimes compromising system's performance. Even in this case this system present a better option than changing the system's code every time a new characteristic relevant to be to observed is introduced by a user.

## 6. Related Work

The PLP works like a Security Policy of Information Systems and its security configurable aspects. A Security Policy (Stallings, 2006) is configurable, similarly to the PLP, i.e. by defining a set of rules and procedures that aim to manage information in the system's security activities.

Regarding certain aspects, the Munich Reference Model for Adaptive Hypermedia (Koch & Wirsing, 2002) and the UML state machine based model (Dolog & Nejdl, 2003)share characteristics with the model presented in this chapter.

The Munich Reference Model provides a basis for the development of adaptive hypermedia applications. Its distinctive characteristic is to have a user model and an adaptation model, a dynamic acquisition of the user behaviour, a dynamic rule-based adaptation, and a user behaviour triggered run-time session. The model has a three-layer structure that includes user modelling and adaptation aspects.

Dolog and Nejdl (Dolog & Nejdl, 2003) explain how UML state diagram models for navigation and class diagrams for user modelling can be used for generating adaptive navigation sequences. The UML state machine based model focus on user interaction and user's and system's generated events in navigation.

## 7. Conclusion and further work

This chapter presented a novel conceptual model for adaptive e-learning systems. This model enables the system to adapt to the student, encouraging knowledge construction, and aiming that the e-learning process be a rich, motivating and significant experience.

The chapter introduced the concept of a PLP in the context of a Learning Management System. The PLP allows one more degree of flexibility in the e-learning system, adding the features of configuration and reusability to the system. The Orientation Layers structure allows that the teacher or instructional designer define and configure in the student profile the aspects that are considered relevant.

In this sense, the model presented provides personalisation and adapts not only to final users, in this case students but also adapts to others users as teachers and instructional designers. Finally some concerns about privacy and how the model treats privacy and personalisation simultaneously without the need of reprogramming system's software are presented.Further work includes evaluating the conceptual model either by proof or experiment and the inclusion of other models to determine students' profiles. In, addition, there are plans to apply some cognitive researches results to create a Layer in the Orientation Layers structure proposing pedagogical strategies that profit from these researches to stimulate and improve student's knowledge construction.

## 8. References

Advanced Distributed Learning (ADL). Sharable Content Object Reference Model (SCORM) Version 1.2. Available: http://www.adlnet.org/Pages/Default.aspx, accessed April,2009.

Brusilovsky, P. Methods and techniques of adaptive hypermedia. User Modelling and User Adapted Interaction; 6(2-3), pp. 87-129,1996.

Brusilovsky, P. Adaptive hypermedia. User Modelling and User-Adapted Interaction 11(1-4), pp. 87-110, 2001.

Dolog, P. and Nejdl, W. Using UML and XMI for Generating Adaptive Navigation Sequences in Web-Based Systems, in P. Stevens, J. Whittle, and G. Booch (eds.), Proc. of UML 2003 - The Unified Modeling Language, pp. 205-219, Springer Verlag, Berlin, 2003.

Koch, N. and Wirsing, M. The Munich Reference Model for Adaptive Hypermedia Applications, in P. de Bra, P. Brusilovsky, and R. Conejo (eds.), Proc. of 2nd Int. Conf. on Adaptive Hypermedia and Adaptive Web-based Systems, pp. 213-222, Springer Verlag, Berlin, 2002.

Kobsa,A. Privacy-enhanced Personalization, Communications of the ACM, Vol.50,No. 8, August 2007.

Gardner, H. Multiple intelligences: The theory in practice, Basic Books, New York, 1993.

Martinez, M. and Bunderson, C.V. Foundations for Personalized Web Learning Environments. Asynchronous Learning Networks Magazine 4(2), 2000. Avalable: http:// www.aln.org/publications/magazine/v4n2/burdenson.asp

Martinez, M. What is Personalized Learning? What is Personalized Learning? E-Learning Developer's Journal, May, 2002. Available: http://www.elearningguild.com/ pdf/2/050702dss-h.pdf , accessed April,2009.

Stallings, W. Cryptography and Network Security: Principles and Practice, 4th Ed., Prentice Hall, 2006.


**E-learning**

Edited by Maja Jakobovic

ISBN 978-953-7619-95-4
Hard cover, 312 pages
**Publisher** InTech
**Published online** 01, February, 2010
**Published in print edition** February, 2010

E-Learning is a vast and complex research topic that poses many challenges in every aspect: educational and pedagogical strategies and techniques and the tools for achieving them; usability, accessibility and user interface design; knowledge sharing and collaborative environments; technologies, architectures, and protocols; user activity monitoring, assessment and evaluation; experiences, case studies and more. This book's authors come from all over the world; their ideas, studies, findings and experiences are a valuable contribution to enriching our knowledge in the field of eLearning. The book is divided into three sections. The first covers architectures and environments for eLearning, while the second part presents research on user interaction and technologies for building usable eLearning environments, which are the basis for realizing educational and pedagogical aims, and the final last part illustrates applications, laboratories, and experiences.



**InTech Europe**
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

**InTech China**
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821