# Adapting instructional hypermedia content to cognitive profiles

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## Abstract

Most existing web based distant education environments take into consideration the notion of *student profile*. Despite the significant variability of the content of such profiles, some common features are commonly encountered, such as initial level of knowledge, progress indicators, and learning objectives. Few systems consider cognitive aspects when modelling student profile. The objective of our work is to investigate this latter issue. We are currently developing a student model based on cognitive parameters that include learning styles, social factors, perception preferences, motivation factors, among others. The methodology adopted is to validate this profile through experimental study and to develop an adaptive hypermedia education system that automatically learns student profile and adapts learning materials accordingly. This papers presents an overview of the objectives and the methodology of this work.

## 1 Introduction

Distant education has recently experienced a significant evolution. The advent of the Internet has improved delivery and management issues. However, a new challenge has been raised by this evolution: the pedagogy and the personalisation of the instruction. Fisher G. 2001 states that "*the challenge in an information-rich world is not only to make information available to people at any time, in any place, and any form, but also to say the right thing at the right time in the right way*" [4].This has created a natural convergence between two research communities interested in hypermedia educational systems on one hand, and intelligent tutoring systems on the other hand. A number of ongoing research efforts are concentrating on ways of taking into consideration the differences and diversity of learning experiences and styles. The ultimate objective being the possibility of adapting education to individual students.
Considering the evolution of the web technology, it becomes possible to envisage learning management systems that allow instructional designers to develop learning resources that can be personalised to learners' profiles. Therefore, implementing pedagogical forms that facilitate students' understanding and assimilation. Such systems have inherited architectures of Intelligent Tutoring Systems which are centred on four main parts: domain model, student model, teaching strategies, and tutor interface. A standardisation effort has been started to develop common methods to structure and interoperate materials related to these various parts [6].

## 2 Principles and mechanisms of adaptation

The earliest forms of personalisation, used in some systems, were restricted to setting user interface parameters and some other preferences. This type of *adaptation* requires explicit choices from the user. Systems that offer such functionalities are commonly referred to as being *customisable*. User choices are considered as a user profile or model. They are stored within the system and used to adapt its environment. This technique assumes that all adaptable aspects are understandable to the user who can clearly identify his/her preferences, and that all preferences can be derived from a pre-test or a questionnaire. Obviously, this approach cannot cope with complex user models. Consequently, a new generation of systems, called adaptive systems, is being developed. Presumably, these systems have the *ability* to adapt to every individual user by analysing logs or by monitoring user interactions [5].

They use essentially two adaptation techniques: adaptive presentation and adaptive navigation support [1].
Systems that support adaptive navigation structure their contents hierarchically. Hyperlinks allow the user to navigate between chapters and sections. Two techniques are used to implement adaptive navigation: adaptive annotation and curriculum sequencing. The first technique changes the order or availability of hyperlinks. Whereas the second makes decision about which chapter or section to visit next depending on prerequisites and achievement. For example, in [2], when starting a chapter, the student undergoes a pre-test to verify prerequisites. Failing to pass the pre-test, the user is not allowed to browse through the material. At the end of the chapter, the student is assessed against learning objectives. The results of such assessment are also used to update the student's profile. In [3], a multi-layered overlay model is used to implement adaptive navigation. Most of these approaches focus exclusively on the level of knowledge that the student processes. They do not consider other factors, especially cognitive, that differentiate learners. Systems that support adaptive presentation offer choices between different media when presenting materials. That is, in addition to traditional text, they can also use music, video, speech, and animation [1].
Most of these techniques are limited when applied to advanced distant learning systems. The learning process is complex and requires taking into consideration various individual parameters that go beyond the assessment of student's achievements and simple user preferences.

## 3 The proposed approach

In this thesis, we address the problem of adapting instruction to the student's cognitive profile. We assume that the cognitive learning style influences the learning behaviour. And we define the cognitive learning profile as being the way an individual tackles a learning task. This profile depends on various factors including cognitive, psychological, emotional, and social aspects. Three main aspects will be considered in this work: modelling the cognitive learning profile, developing an adaptive system that automatically assesses and uses such profile, contribute to enhancing existing distant education standards ( such as ADL-SCORM) to take into consideration cognitive profiles.

### *3.1 Cognitive learning profile*

In the rich educational psychology literature, various definitions and models have been proposed for learning styles and cognitive models. Recently, some researchers have started using some of these models to optimise the design and delivery of interactive learning resources [3, 6, 7, 8]. In [7], the authors used a study to assess the cognitive learning styles of students. They also analysed navigation logs of these students when using an experimental interactive course. Based on this analysis, they identified five categories of learning styles and correlated them with navigation behaviours.
Our objective is to develop a student model that integrate various individual characteristics such as perception, thinking style, social aspects, and motivation factors. An experimental study will be conducted using a questionnaire and a simulated learning environment with a large number of university students. This study will help us develop and validate the student model.
Our study will start with the assessment of the perception and the presentation of information on the performance of students during a learning task. The objective of this phase is to propose a general model for adaptive learning systems that can dynamically author learning materials depending on the learning objective and the characteristics of the user. Learners with some disabilities could be the target population of this application [4].

### *3.2 Adaptive tutoring system*

Based on the results of the user modelling, we will design a system that can optimise instruction to individual students. The system will be able to dynamically learn the user profile. The automatic learning process will be continuous and by reinforcement. An adaptation algorithm will match the student profile to the learning objectives and environment. Among other aspects, the level of complexity, nature of material (e.g., example-based, problem-based, model-based, simulation), the type of activity (e.g., individual, group, coaching, tutor interaction), and the mode of presentation (e.g.,

text, graphics, pictures, sound, video) will be decided. A dynamic authoring module will generate the actual content.

### *3.3 Enhancing existing standards*

Since the late nineties, a great effort has been deployed to standardise computer and web based educational technology. The objective of this standardisation is to coordinate and integrate the work of various research communities and allow the emergence of a real economy related to the production and distribution of advanced distant learning materials. Interoperability is one of the main challenges of these standards. In order to achieve this objective, standards have focused mainly on the structure, description, and packaging of learning resources. SCORM [6] is the most integrated model. It proposes a way of structuring content (content aggregation model) based on the notion of shared content objects, standard metadata to describe the content, and a run time environment to operate the content and track the user progress. Although the model is intended to encourage the development of a new generation of intelligent tutoring systems, no sophisticated pedagogical approaches are considered. Some enhancement have been proposed concerning adaptive presentation [9, 10, 11]. To our knowledge, no work has yet addressed the integration of adaptation to cognitive profiles into the SCORM model. We intend to address this issue and to propose an additional layer to the model allowing it to manipulate multiple media, pedagogical activities (especially active pedagogies like project based learning), and related resources and environments that make possible the implementation of advanced adaptive systems.

## 4 Conclusion

This paper has presented an overview of a starting thesis. This thesis aims at investigating adaptive web based teaching to individual cognitive profiles of students. The work addresses three complementary aspects: student modelling using individual cognitive and social characteristics, the development of an adaptive hypermedia tutoring system that automatically *learns* the student profile and adapt content, activity and mode of presentation, the contribution to the enhancement of the SCORM model by integrating new components allowing the implementation of adaptive systems.

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