Chapter 6
A Hybrid Architecture for Adaptive, Intelligent, and Ubiquitous Educational Systems

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ABSTRACT

Ubiquitous learning environments (ULEs) allow real and virtual study materials to be combined to enrich learning experiences. Classrooms equipped with electronic devices produce artifacts that can reconstruct the captured experiences for later use and review. Those environments have the potential to turn themselves into a factory of learning objects (LOs), which may become useless if appropriate means for reaching them are not provided to students. On the other hand, adaptive educational hypermedia (AEH) have appeared as a way of personalizing educational content in web environments and modern intelligent tutoring systems (ITS) provide personalized resources for automating pedagogical tasks. In this way, this chapter explores the concept of ULEs together with AEH and ITS for generating and providing personalized LOs to students. The proposed approach is grounded in artificial intelligence, pedagogical concepts, and computational systems technologies such as ontologies, Bayesian networks, learning styles, and ULEs for creating better individual learning experiences.

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INTRODUCTION

Computers have become everyday tools within the contemporary classroom. Laptops, tablets, smartphones, interactive whiteboards, and other electronic devices are constantly used to support both instructors and students in their teaching/learning tasks, providing educational content and activities that can accessed anywhere and anytime. This is related to the concept of Ubiquitous Computing (Weiser, 1991) and, when applied to educational settings, it can be called Ubiquitous Learning Environments (ULEs).

ULEs combine real and virtual learning environments to produce richer study artifacts, ideally in the form of Learning Objects (LOs), to allow proper standardization and reuse (Labib, Penadés, Canós, & Gómez, 2015). Such environments, however, usually produce a huge volume of unstructured content, which makes the processes of retrieval and presentation a true challenge for this type of computing system.

In addition, Adaptive Educational Hypermedia (AEH) have appeared to deal with the issue of educational content personalization in Web environments, while modern Intelligent Tutoring Systems (ITS) aim at providing personalized resources for automating pedagogical tasks.

Chapter Objectives

Considering the convergence of all these ideas in the educational scenario, this chapter aims at exploring the concepts of AEH and ITS together with ULEs for generating and providing personalized LOs to students. More specifically, this chapter provides the reader an overview of key challenges in the area of personalized learning, with our most recent efforts to address them, as well as a summary of our last research results:

- Dynamic adaptation of educational content has been an important research topic that creates intelligent techniques to adapt educational content to the real needs of students. The goal is to provide a more personalized and individualized learning experience. Therefore, in order for the underlying infrastructure to run effectively, we present a student model that properly describe and monitor the cognitive state of students. Our approach includes a hybrid student model that combines an ontology and a Bayesian Network to identify students' knowledge based on their characteristics and behavior while using an Adaptive Educational System.
- Thereby, this chapter aims at presenting the design of a computational architecture capable of automatically structuring LOs captured in instrumented classrooms, including their metadata, as well as offering content personalization and recommendation features to students in ULEs. The term hybrid architecture is used to indicate a computational infrastructure that considers a mix of different strategies, technologies, theories, and approaches, such as ULEs, LOs, AEH, and ITS. Experiments have been performed with real participants – students and instructors – in higher education courses using an experimental prototype developed to verify the viability of the approach, which have shown satisfactory and promising results.
- In addition, with the increasing amount of educational content available, there is a good reason to believe that smart data analysis will become even more pervasive as a necessary ingredient for the progress of AEH and ITS. Machine Learning techniques, for example, are potentially useful for extracting hidden information from raw data and present it in a comprehensible form. In this context, the results presented in this chapter are complementary to a more general approach to analyze and organize existing repositories of LOs using clustering algorithms and ontologies.