# Chapter 1
# Techniques, Technologies and Patents Related to Intelligent Educational Systems

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## ABSTRACT

*E-learning systems play an increasingly important role in lifelong learning. Tailoring the learning process to individual needs is a key issue in such systems. Intelligent Educational Systems (IESs) are e-learning systems employing Artificial Intelligence methods to effectively adapt to learner characteristics. Main types of IESs are Intelligent Tutoring Systems (ITSs) and Adaptive Educational Hypermedia Systems (AEHSs) incorporating intelligent methods. In this chapter, the authors present technologies and techniques used in the primary modules of IESs and survey corresponding patents. They present issues and problems involving specific IES modules as well as the overall IES. The authors discuss solutions offered for such issues by Artificial Intelligence methods and patents. They also discuss categorization aspects of patents related to IESs and briefly present the work described in some representative patents. Lastly, the authors outline future research directions regarding IESs.*

## INTRODUCTION

The need for lifelong learning is becoming increasingly evident involving education institutes, public/private sector organizations, companies, research centers, tutors, employees and learners. As knowledge constantly evolves, lifelong learning becomes necessary for almost everybody. Learning throughout life becomes a necessity for personal, professional and social reasons (Jarvis, 2008). Lifelong learning plays an important role in enhancing personal knowledge, social inclu-

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sion and employability. Furthermore, in modern society, people and organizations undergo processes of transition. Each one must be prepared for transitions, engaging in lifelong learning as a fundamental strategy for handling change (Field, Gallacher, & Ingram, 2009). A main driving force of lifelong learning is e-learning. Numerous computer-based systems have been developed for education during the last decades. Such systems are usually addressed to school students, pre-graduate and post-graduate university students, employees of organizations/companies, unemployed and generally members of online communities.

An important requirement when e-learning systems are used for lifelong learning is the capability to personalize instruction to the needs and skills of learners. This requirement becomes increasingly vital as the number of learners accessing an e-learning system increases. Learners have different preferences and learning styles, set diverse educational goals and usually have unequal knowledge levels regarding a specific teaching subject. Lack of sufficient spare time due to pressing (family/professional) obligations is a factor frequently resulting in loss of interest when interacting with ineffective e-learning systems. An e-learning system tailored to learner needs/skills saves learners time/effort and motivates participation in learning process. Traditional Computer-Assisted Instruction (CAI) systems are based on shallow representation of teaching domain, learner data and pedagogical methods. It is difficult for them to adjust effectively the learning process as they provide limited ways of adaptation and learner evaluation.

These drawbacks gave rise to a new generation of educational systems encompassing intelligence called *Intelligent Educational Systems* (IESs) (Aroyo, Graesser & Johnson, 2007; Brusilovsky & Peylo, 2003). IESs incorporate Artificial Intelligence (AI) techniques/mechanisms to model learners as well as knowledge regarding the teaching subject and tailor learning experience to learner needs. Main IES types are Intelligent Tutoring Systems (ITSs) and Adaptive Educational Hypermedia Systems (AEHSs) using intelligent methods. IESs support lifelong learning as they provide personalized instruction. IESs place lifelong learners at centre stage by making them more responsible for the results of the learning process (Drachsler, Hummel, & Koper, 2008). Due to the fact that IESs can be used effectively in different contexts, they satisfy lifelong learning requirements. IES functionality can be used in education institutes but can be also integrated into workplace learning and personal development.

An interesting aspect of IESs is their constant evolution by exploiting advances in Web-based technologies, AI techniques and Computer Science in general. Advances in these fields provide the impetus to develop advanced IES applications that satisfy learning necessities not covered by previous systems. Various AI methods have been applied to IESs, enabling implementation of several online/offline intelligent functions to accommodate different IES user types. Use of several AI methods in IESs has been vastly explored. However, use of certain other AI methods has not been adequately explored.

Figure 1 depicts an IES's basic architecture. It mainly consists of the following components: (a) *domain knowledge*, which contains learning content and information about the learning subject, (b) *user (or student) modeling unit*, which records learner information, (c) *pedagogical module*, which encompasses knowledge regarding various pedagogical decisions, (d) *user interface*, which communicates with users.

Sometimes, an extra component is considered, namely *expert module*. Expert module typically deals with interactive problem solving, e.g. with providing intelligent help. It acts as an expert (tutor) who supervises learners as they solve problems and gives advice, hints, examples etc. This module can be considered as part of pedagogical module in Figure 1.

In this chapter, we outline technologies and techniques used in ITSs and AEHSs, in all their