Artificial Intelligence and Education

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INTRODUCTION

Governments and institutions are facing the new demands of a rapidly changing society. Among many significant trends, some facts should be considered (Silverstein, 2006): (1) the increment of number and type of students; and (2) the limitations imposed by educational costs and course schedules. About the former, the need of a continuous update of knowledge and competences in an evolving work environment requires life-long learning solutions. An increasing number of young adults are returning to classrooms in order to finish their graduate degrees or attend postgraduate programs to achieve an specialization on a certain domain. About the later, due to the emergence of new types of students, budget constraints and schedule conflicts appear. Workers and immigrants, for instance, are relevant groups for which educational costs and job incompatible schedules could be the key factor to register into a course or to give up a program after investing time and effort on it. In order to solve the needs derived from this social context, new educational approaches should be proposed: (1) to improve and extend the online learning courses, which would reduce student costs and allows to cover the educational needs of a higher number of students, and (2) to automate learning processes, then reducing teacher costs and providing a more personalized educational experience anytime, anywhere.

As a result of this context, in the last decade an increasing interest on applying computer technologies in the field of Education has been observed. On this regard, the paradigms of the Artificial Intelligence (AI) field are attracting an special attention to solve the issues derived from the introduction of computers as supporting resources of different learning strategies. In this paper we review the state-of-art of the application of Artificial Intelligence techniques in the field of Education, focusing on (1) the most popular educational tools based on AI, and (2) the most relevant AI techniques applied on the development of intelligent educational systems.

EXAMPLES OF EDUCATIONAL TOOLS BASED ON AI

The field of Artificial Intelligence can contribute with interesting solutions to the needs of the educational domain (Kennedy, 2002). In what follows, the type of systems that can be built based on AI techniques are outlined.

Intelligent Tutoring Systems

The Intelligent Tutoring Systems are applications that provide personalized/adaptive learning without the intervention of human teachers (VanLehn, 2006). They are constituted by three main components: (1) knowledge of the educational contents, (2) knowledge of the student, and (3) knowledge of the learning procedures and methodologies. These systems promise to radically transform our vision of online learning. As opposed to the hypertext-based e-learning applications, which provide the students with a certain number of opportunities to search for the correct answer before showing it, the intelligent tutoring systems perform like coaches not only after the introduction of the response, but also offering suggestions when the students doubt or are blocked during the process of solving the problem. In this way, the assistance guide the learning process rather than merely saying what is correct or what is wrong.

There exist numerous examples of intelligent tutoring systems, some of them developed at universities as research projects while others created with business goals. Among the first ones, the *Andes* systems (VanLehn, Lynch, Schulze, Shapiro, Shelby, Taylor, Treacy,

Weinstein & Wintersgill, 2005), developed under the guidance of Kurt VanLehn of the University of Pittsburg, is a popular example. The system is in charge of guiding the students while they try to solve different sets of problems and exercises. When the student ask for help in the middle of an activity, the system either provides hints in order to step further towards the solution or points out what was wrong in some earlier step. *Andes* was successfully evaluated during 5 years in the Naval Academy of the United States and can be downloaded for free. Another relevant system is *Cognitive Tutor* (Koedinger, Anderson, Hadley & Mark, 1997), is a comprehensive secondary mathematics curricula and computer-based tutoring program developed by John R. Anderson, professor at the Carnegie Mellon University. The Cognitive Tutor is an example of how research prototypes can be evolved into commercial solutions, as it is nowadays used in 1,500 schools in the United States. On the business side, Read-On! is presented as a product that teaches reading comprehension skills for adults. It analyzes and diagnoses the specific deficiencies and problems of each student and then adapts the learning process based on that features (Read On, 2007). It includes an authoring tool that allows course designers to adapt course contents to different student profiles in a fast and flexible way.

Automatic Evaluation Systems

Automatic Evaluation Systems are mainly focused on evaluating the strengths and weaknesses of students in different learning activities through assessment tests (Conejo, Guzmán, Millan, Trella, Perez-de-la-Cruz. & Rios, 2004). In this way, these systems not only perform the automatic correction of the test, but also derive automatically useful information about the competences and skills obtained by the students during the educational process.

Among the automatic evaluation systems, we could highlight *ToL* (Test On Line) (Tartaglia & Tresso, 2002), which have been used by Physics students in the Polytechnic University of Milano. The system is composed of a database of tests, an algorithm for question selection, and a mechanism for the automatic evaluation of tests, which can be additionally configured by the teachers. *CELLA* (Comprehensive English Language Learning Assesment) (Cella, 2007) is another system that evaluates the student competence on using and understanding the English language. The application shows the progress carried out by the students and determines their proficiency and degree of competence on the use of foreign languages. As for commercial applications, *Intellimetric* is a Web-based system that lets students to submit their work online (Intellimetric, 2007). In a few seconds, the AI-supported grading engine automatically provides the score of the work. The company claims a reliability of 99%, meaning that 99 percent of the time the engine´s scores match those provided by human teachers.

Computer Supported Collaborative Learning

The environments of computer supported collaborative learning are aimed at facilitating the learning process providing the students both the context and tools to interact and work in a collaborative way with their classmates (Soller, Martinez, Jermann & Muehlenbrock, 2005). In intelligent-based systems, the collaboration is usually carried out with the help of software agents in charge of mediating and supporting student interaction to achieve the proposed learning objectives.

The research prototypes are the suitable test-beds to prove new ideas and concepts, to provide the best collaborative strategies. The *DEGREE* system, for instance, allows the characterization of group behaviours as well as the individual behaviours of the people constituting them, on the basis of a set of attributes or tags. The mediator agent utilizes those attributes, which are introduced by students, in order to provide recommendations and suggestions to improve the interaction inside each group (Barros & Verdejo, 2000). In the business domain there exist multiple solutions although they do not offer intelligent mediation to facilitate the collaborative interactions. The *DEBBIE* system (DePauw Electronic Blackboard for Interactive Education) is one of the most popular (Berque, Johnson, Hutcheson, Jovanovic, Moore, Singer & Slattery, 2000). It was originally developed at the beginning of year 2000 at the University of Depauw, and managed later by the DyKnow company, which was specifically created to make profit with *DEBBIE* (Schnitzler, 2004). The technology that currently offers DyKnow allows both teachers and students to instantaneously share information and ideas. The final goal is to support student tasks in the classroom by eliminating the need of performing simple tasks, as for instance backing up the teacher's presentations. The students could therefore