Cognitive and Metacognitive Educational Systems:
Papers from the AAAI Fall Symposium (FS-09-02)

Preface
Why Metacognition in Modern Educational Systems?

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Artificial learning systems such as e-learning, multimedia and hypermedia, and Intelligent Tutoring Systems (ITS) are designed to support learning processes in order to facilitate the acquisition, development, use, and transfer required to solve complex tasks. Besides their trivial duties regarding content management, these systems have to interact with different users, and support them with several decisional processes. One of the most critical decisions includes those dealing with aspects of self-regulation.

Students need to learn to regulate their learning, that is, they need to plan their learning activities, to adapt their learning strategies to meet learning goals, become aware of changing task conditions, and dynamic aspects of the instructional context, to monitor and control their cognitive processes and behavior, and to evaluate their performance. In addition, students must also regulate their affect and motivation prior to, during, and after they have used artificial systems. This is a critical aspect of being a regulating agent. Interdisciplinary research on the role self-regulation is emerging with learning environments is merging from the fields of cognitive, learning, and computational sciences.

Students also need very flexible systems that are able to provide visualization and browsing of multi-representational materials according to the students learning profile. These systems have to exhibit a very tight interaction between learner characteristics (for example, expert, child), and the mediating regulatory processes that dynamically fluctuate between internal (for example, students cognitive architecture) and external (for example, presence of a human tutor, feedback system) conditions within a particular learning context.

Teachers and other external regulating agents (for example, human tutor) have to adapt by externally regulating aspects of the environments, learning system, and/or the learners. For example, an external regulating agent may have to modify their student model and therefore alter the sequence of the domain knowledge, and fit concepts and relations into the systems knowledge base. These users need very easy-to-use tools to visualize the domain for design purposes, and to control the acquisition of self-regulatory skills, systems ability to stimulate knowledge elicitation, and to integrate new knowledge from either different authors or some external repository (that is, internet resources like wikis, folksonomies, and so on).

Human or artificial tutors have to continuously and dynamically monitor and model all of the students activities (including problem solving processes, deployment of regulatory processes, and so on), make complicated inferences about them, to ensure that learning is maximized. Students and tutors need decision support capabilities in terms of social networks analysis, visualization tools of students behaviors in relation to the domain knowledge to be explored, and linguistic tools to analyze their sentences in forums and chats.

Traditional intelligent (that is, rational) systems fail in achieving all the above-mentioned goals. A paradigm shift is needed in this respect. The artificial systems in support of education have to be "cognitive or better they have to use metacognition. A metacognitive system is self-aware and might use self-regulation to stimulate the deployment of self-regulatory processes in the user. This sort of cognitive push-pull can be enabled only via multimodal interaction where the linguistic modality as well as other detector (for affect, motivation, and behavioral monitoring and control) is very crucial. The possibility to define a systems "mental state can enable it to increase autonomously its knowledge to support the user in his or her decisional processes. These issues represent a key barrier in the development of intelligent adaptive learning systems capable of externally regulating students learning. In recent years there was a growing interest inside different disciplines towards the development of metacognition in traditional educational systems. The main actors of this process come from educational psychology and artificial intelligence. In a few years, several international journals in both areas have published many papers related to cognitive architectures and education, and a dedicated conference (AIED) has been instituted to encourage crossing between researchers in these areas. Right now, educational psychologists and AI researchers have followed parallel paths without effective hybridization.

The aim of the Cognitive and Metacognitive Educational Systems 2009 AAAI symposium was to stimulate the creation of a dedicated research community about the definition of what is a metacognitive educational system. What aspects of cognition, metacognition, affect, and motivation have to be explored and integrated to achieve the goal of a new generation of metacognitive tools for enhancing learning in educational systems? Finally, what are the architectural issues

to design these systems?

In this respect, we obtained contributions from researchers in different disciplines: AI, cognitive and learning sciences, education psychology, HCI, computational linguistics, web technologies, social network analysis, visualization techniques, software architectures, and agents systems.

Our main goal in organizing this symposium was to have an intense debate about these topics. In this respect, panel discussions have been favored, and a joint session with the Biologically Inspired Cognitive Architectures 2009 AAAI symposium has been arranged with speakers coming both from US government agencies and EU commission to have a global vision of the research perspectives in this area.

Finally, some outstanding scientists and professionals in some of the research areas already mentioned, served as keynote speakers to provide the attendees with theoretical deepening. Some abstracts of their talks are reported in this report.