

## Invited Speaker Abstracts

**Stephen Grossberg, Kurt VanLehn, Cristina Conati, Arthur C. Graesser, John C. Cherniavsky**

### **How the Brain Learns in Health and Disease: Towards Understanding the Many Factors that Influence Effective Learning**

*Presented by Stephen Grossberg, Department of Cognitive and Neural Systems, Center for Adaptive Systems, and Center of Excellence for Learning in Education, Science, and Technology, Boston University, Boston, MA 02215*

A deep and rational understanding of the factors that influence effective education and learning technologies depends on a corresponding understanding of how the brain in health and disease controls learned behaviors. There has been a revolution in discovering new computational paradigms, organizational principles, mechanisms, and models of how learning processes enable brains to give rise to minds. This talk will begin with a review of what this revolution is, what some of the new paradigms are, and what modeling methods can effectively link mind to brain on multiple levels. It will then survey, in the time available, a variety of the brain's learning mechanisms and modulators that can influence whether learning is effective or not, and indeed whether it becomes imbalanced in ways that are characteristic of mental disorders. Examples will be taken from cognitive working memory and learned planning, cognitive-emotional interactions, recognition learning, reinforcement learning, spatial attention and visual search, adaptive timing of behavior, and adaptive sensory-motor control. How such processes break down in mental disorders such as autism, schizophrenia, and amnesia will also be noted, and used to illustrate how learning processes that are needed for effective learning can break down. See [cns.bu.edu/~steve](http://cns.bu.edu/~steve) for models of these various processes.

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### **How Can a Tutor get Students to Keep Using a Metacognitive Strategy After the Tutoring Stops?**

*Presented by Kurt VanLehn, Department of Computer Science and Engineering, Arizona State University*

metatutors have successfully coached students to use domain-general strategies such as self-explanation (for example, Chi, de Leeuw, Chiu and LaVanher, 1994), self-regulatory strategies (for example, Azevedo, Greene and

Moos, 2007; Biswas, Leelawong and Schwartz, 2005) and the proper use of a tutor's hints (for example, Roll, Aleven, McLaren and Koedinger, 2007). Unfortunately, many students stop using these beneficial learning practices as soon as the metatutoring ceases. Apparently, the metatutors were nagging rather than convincing. This talk will present a study of Pyrenee, a metatutor that coaches students to focus on learning domain principles rather than solutions to examples. It was convincing, in that students who were taught probability with Pyrenee used principle-based problem solving on post-test more so than students taught by Andes, which did not focus students on principles. Moreover, when all students were transferred to Andes for learning of physics, those who were metatutored used the principle-focused strategies even without the nagging of a metatutor. On a variety of measures, the effect sizes for both probability and physics were 1.0 or larger.

### **Modeling Student Metacognitive Skills and Affective States in Education Systems**

*Presented by Cristina Conati, Computer Science Department and Laboratory for Computational Intelligence University of British Columbia*

Student modeling has played a key role in the success of computer-based tutors known as intelligent tutoring systems (ITS), by allowing these systems to dynamically adapt to a student's knowledge and problem solving behavior. In this talk, I will discuss how the scope and effectiveness of ITS can be further increased by enabling these systems to capture a student's domain independent metacognitive skills and affective states. In particular, I will illustrate how we are applying this research to novel forms of pedagogical interactions designed to provide student-adaptive support to studying examples, exploring interactive simulations and playing educational games.

### **Computer Agents that Improve Metaknowledge in Tutorial Dialogue**

*Presented by Arthur C. Graesser, Department of Psychology and Institute for Intelligent Systems, University of Memphis*

Metaknowledge is knowledge that the student or tutor has about cognition, emotions, communication, and pedagogy. Metaknowledge is necessary for learners who want to take command of their learning experiences in a self-regulated

manner and for tutors who want to optimize the students' learning and motivation. It is well documented, however, that metaknowledge is quite limited for most students and tutors. This presentation describes five illusions that illustrate such limitations. Therefore, it is worthwhile to consider computer-based training environments for improving metaknowledge proficiency. One class of learning environments uses animated conversational agents that hold conversations with students in natural language. This presentation discusses some agent-based environments that help students learn at deeper levels and that also improve metaknowledge. For example, AutoTutor helps students build explanations while answering difficult questions on topics in science and technology. AutoTutor takes an indirect approach to promoting metaknowledge by tracking of the student model that is inferred from the learner's language and to intelligently respond to the student with a wide range of discourse moves, including those that attempt to improve metaknowledge. This fine-grained adaptivity considers the emotional states of the learner in addition to the cognitive states and the discourse states of the exchange. A second approach is to directly train students on the fundamentals of metaknowledge, which is an approach taken by iSTART, MetaTutor, SEEK Web Tutor, Operation ARIES!, and some other agent-based environments.

### **Research in Learning Technologies at NSF**

*Presented by John C. Cherniavsky, Division of Research on Learning in Formal and Informal Settings, Education and Human Resources (EHR) Directorate, National Science Foundation*

It has been almost 50 years since Donald Bitzer developed PLATO 1 — with funding from the Army, Navy, and Air Force — arguably this is the first computer-based learning technology. The National Science Foundation participated in the full development of PLATO through the support of the Computer-based Education Research Laboratory at the University of Illinois starting in 1967 and was involved in other Learning Technology efforts at Stanford University and elsewhere. The National Science Foundation (NSF), along with the Office of Naval Research and the Advanced Research Projects Agency, funded early AI and cognitive science research that led to the development of other intelligent tutoring systems — particularly the Cognitive Tutors now marketed by Carnegie Learning, Inc. Thus there is a long history of NSF involvement in AI research, education research, and research in the behavioral and cognitive science research underpinning Learning Technologies.

With the advent of transformative cyber-infrastructure (for example, high speed networks, large data repositories, sensor networks, and high speed computers that transform research and education), there is a new need for research on how this infrastructure can transform education at all levels. That it is transforming education already can be seen in the transformation of education and research in astronomy. It is no longer necessary, or even desirable, for astronomers to go to telescopes for observations. Observations are automated and automatically stored in data repositories for analysis. Nor is analysis restricted to professional astronomers — the

Galaxy Zoo project engages amateurs in the classification of astronomical objects to enhance science. In addition, with the development of the web (again with NSF involvement through the funding of Mosaic), access to education materials is pervasive — ranging from the desktop to cell phones. Finally new capabilities made possible through Moore's law and the miniaturization of components give new opportunities for providing education resources — for example, GPS capabilities in inexpensive hand-held computers.

The NSF has responded to these changes by encouraging transformative research in learning technologies through programs of research support. During this presentation, I will discuss research support opportunities for learning technologies from the Computer and Information Science and Engineering Directorate, the Education and Human Resources Directorate, the Engineering Directorate, and the Office of Cyber-infrastructure at the NSF.