



Harnessing AI and Multimodal Data to Enhance Metacognitive Development:

A New Era in Self-Regulated Learning with Advanced Learning Technologies

In an age of information abundance and rapid technological advancement, self-regulating one's learning has become a critical skill for academic success and lifelong learning. This keynote address explores the transformative potential of advanced learning technologies, artificial intelligence (AI), and multimodal multichannel trace data in shaping learners' metacognition and self-regulated learning (SRL) processes. I begin by examining the intricate relationship between metacognition—the awareness and understanding of one's cognitive processes—and SRL, which involves the strategic planning, monitoring, and evaluation of learning. Drawing on recent research in cognitive, learning, and educational sciences and AI in education, I demonstrate how these higher-order thinking skills enhance knowledge acquisition and promote transfer, problem-solving, and adaptability in diverse learning contexts. Next, I delve into the emerging landscape of advanced learning technologies, such as intelligent tutoring systems, game-based learning environments, immersive virtual environments, and human digital twins. I showcase how these tools can create immersive, personalized learning experiences that challenge learners to reflect on their strategies, track their progress, and adjust their approaches in real time based on multimodal trace data.

Much of the talk will focus on the untapped potential of multimodal multichannel trace data—including eye-tracking, facial expression recognition, physiological measures, and log data—in understanding and supporting metacognition and SRL. I synthesize recent work on multimodal learning analytics to decode rich data streams, revealing subtle patterns in learners' cognitive load, metacognitive monitoring skills, emotional states, strategy use, and motivational beliefs. From this synthesis, I will highlight the real-time challenges of using these data to support self-regulated learning. These insights enable the design of AI-based "metacognitively aware" systems that can detect impasses, scaffold reflection, and inspire the use and transfer of metacognitive skills across tasks, domains, learners, and contexts. Finally, my talk will conclude with a call to action for interdisciplinary collaboration among interdisciplinary researchers, educators, and technologists to realize the full potential of AI and multimodal data in cultivating self-aware, self-regulating learners equipped for the complexities of the 21st century.



Prof. Dr. Roger Azevedo
University of Central Florida
United States