Benvenuto

- **welcome to our session on adaptive and predictive computer-based tutoring**

- **dare il benvenuto alla nostra sessione su al tutoring adattabile ed indicativo basato su computer**

Session Presentations

- **Dr. Robert Sottilare - Paper #16 - Research Gaps for Adaptive and Predictive Computer-Based Tutoring Systems**
- **Keith Brawner - Paper #8 – Real-time Clustering of Unlabeled Sensory Data for Trainee State Assessment**
- **Dr. Elaine Raybourn - Paper #20 - Incorporating Reflection into Learner Models for Adaptive and Intelligent Tutoring**
- **Dr. Heather Holden - Paper #9 - The Impact of Student Expectations and Tutor Acceptance on Computer-Based Learning Environment Acceptance and Future Usage Intentions**
- **Markus Klug - Paper #4 - Excel-Based Analysis and Dyamisation of Probabilities for Logistics Planning**

U.S. Army Research, Development and Engineering Command

RESEARCH GAPS FOR ADAPTIVE AND PREDICTIVE COMPUTER-BASED TUTORING SYSTEMS

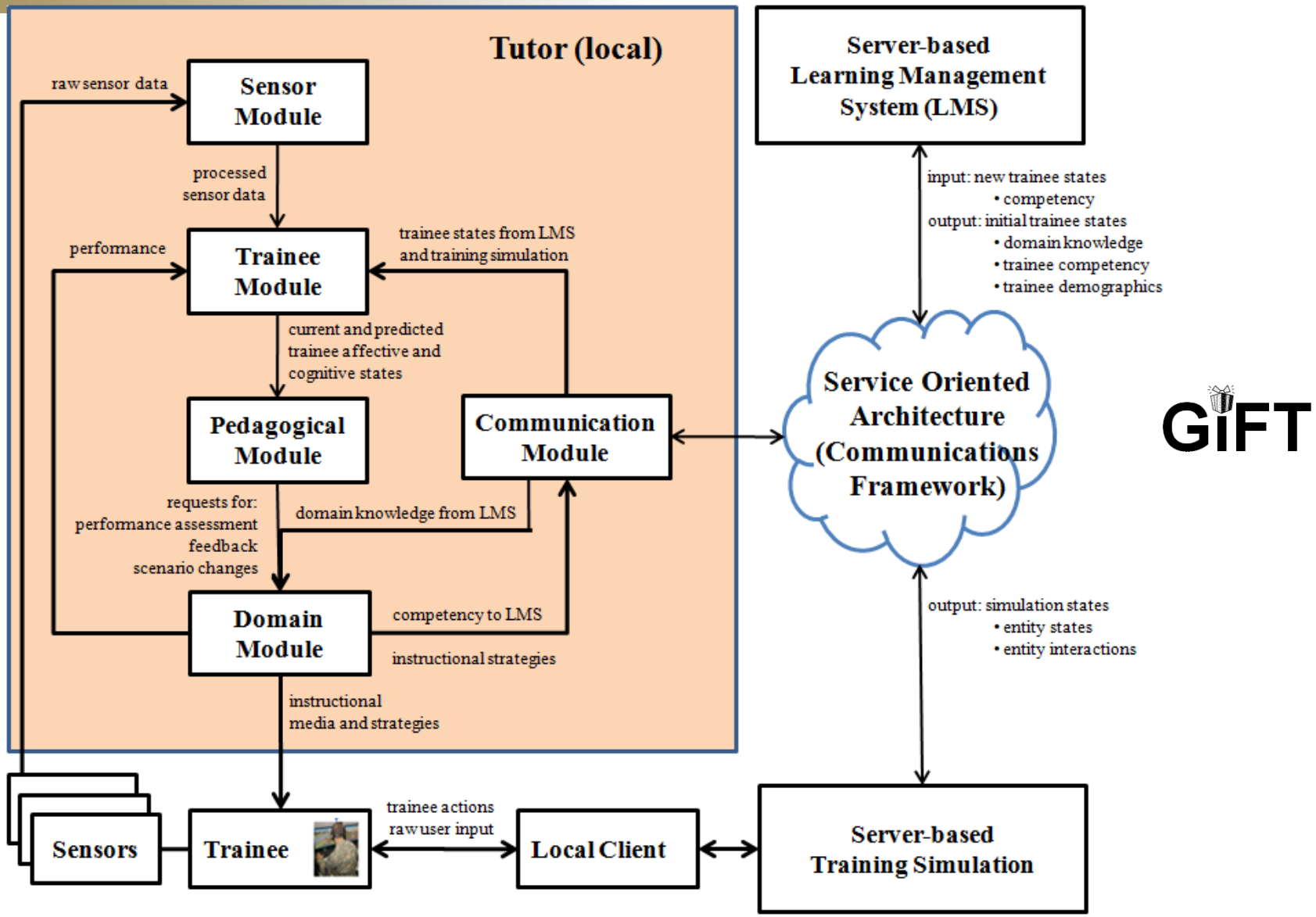
TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Robert A. Sottilare, Ph.D., ARL
Stephen Goldberg, Ph.D., ARI
Paula Durlach, Ph.D., ARI

September 2011 – DHSS, Rome, Italy

LITE Lab

Tutoring Framework for Individual Training



Question of the day…

Why aren't computer-based tutors more prevalent?

Perché i precettori basati su computer non sono più prevalente?

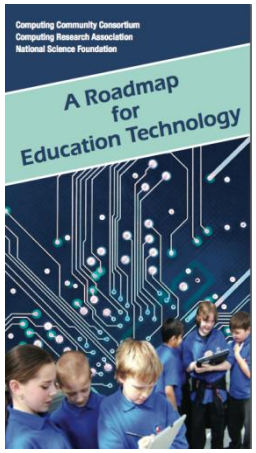
Agenda

- **Computer-based tutoring background and motivation for research**
- **Tutor adaptability and predictive accuracy**
- **Challenges in computer-based tutoring**
  - **student modeling**
  - **authoring tools and expert modeling**
  - **instructional strategy selection**
- **Standards for assessing tutor performance**
- **Recommendations for Future Research**

Computer-based tutoring research motivation

- **Computer-based Intelligent Tutors work: (Woolf, 2011)**
  - **Nearly the same improvement as one-on-one human tutoring.**
  - **Effectively reduce the time required for learning by 1/3 to 1/2.**
  - **Networked versions reduce the need for training support personnel by about 70% and operating costs by about 92%**

- **Grand Challenges for Education Technology (Woolf, 2010)**
  - **Personalize Education**
  - **Assess Student Learning**
  - **Support Social Learning**
  - **Diminish Boundaries**
  - **Develop Alternative Teaching Methods**
  - **Enhance the Role of Stakeholders**
  - **Address Policy Changes**

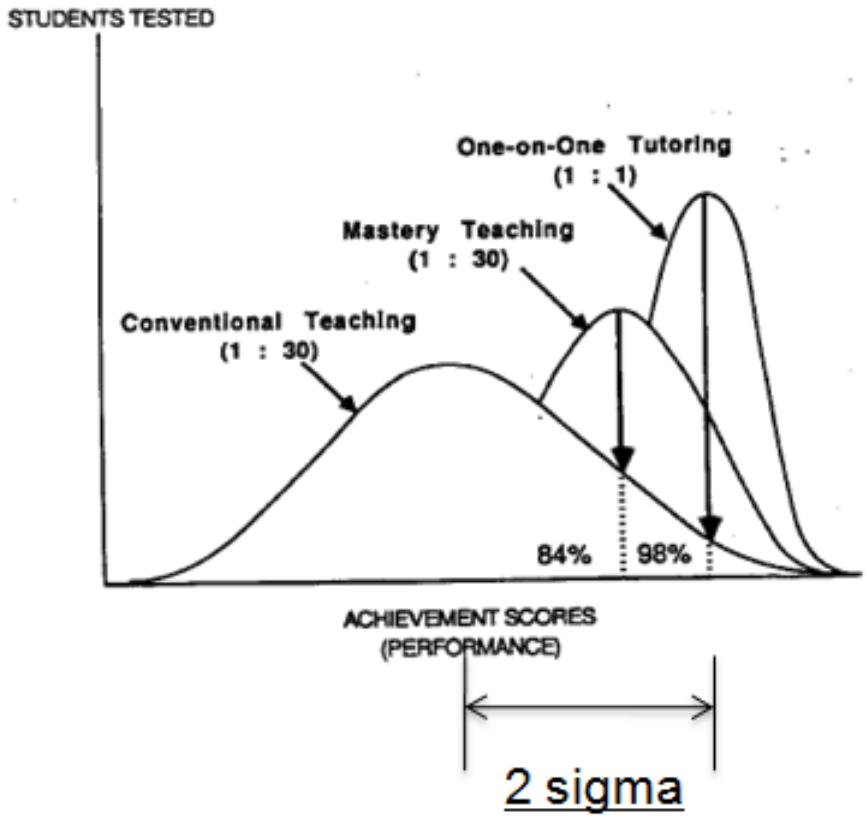


Woolf, B.P. (2011). Intelligent Tutors: Past, Present and Future. Keynote address at the Advanced Distributed Learning ImplementationFest, August 2011, Orlando, Florida.

Woolf, B. P. (2010). *A Roadmap for Educational Technology. National Science Foundation # 0637190*

Payoff: Improved Learning

- **2 sigma improvement for human one-on-one tutoring over conventional teaching (Bloom, 1984)**
- **.50 sigma for interactive multimedia (Woolf, 2011)**
  - **raises the median score from 50% to 69%**
- **1.05 sigma for intelligent tutors (Woolf, 2011)**
  - **raises the median score from 50% to 85%**



Bloom, Benjamin S. (1984) The 2-sigma problem: The search for methods of group instruction as effective as one-to-one tutoring, Educational Researcher 13: 4-16.

Woolf, B.P. (2011). Intelligent Tutors: Past, Present and Future. Keynote address at the Advanced Distributed Learning ImplementationFest, August 2011, Orlando, Florida.

So…

Why aren't computer-based tutors more prevalent?

they need to be more adaptive, predictive and easier to author

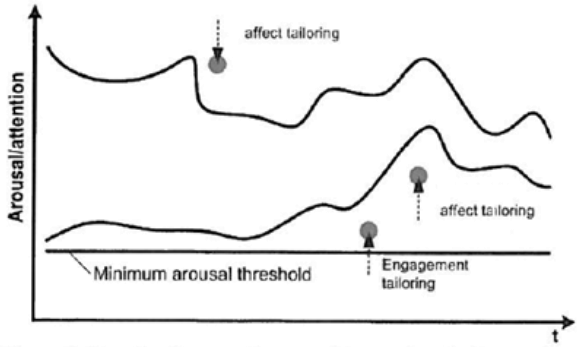
Perché i precettori basati su computer non sono più prevalente?

devono essere più adattabili, preventivi e più facili da creare

Tutor adaptability and predictive accuracy

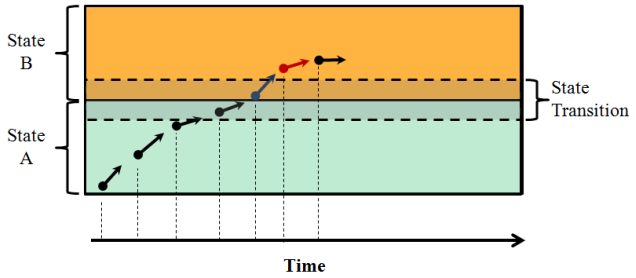
adapt to:

student needs & capabilities
individual differences
motivational state
preferences & experience
cognitive & affect states
proficiency and expertise



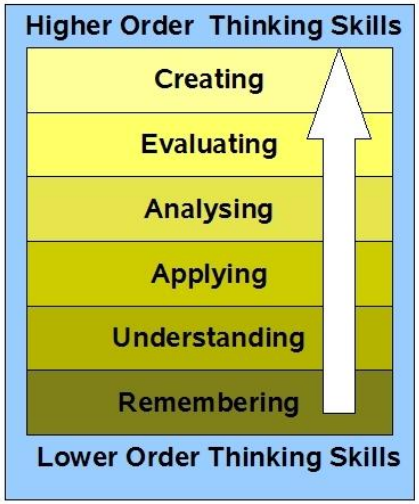
accurately predict:

current and future states
knowledge & skills
performance
motivation
cognition & affect
attention and engagement

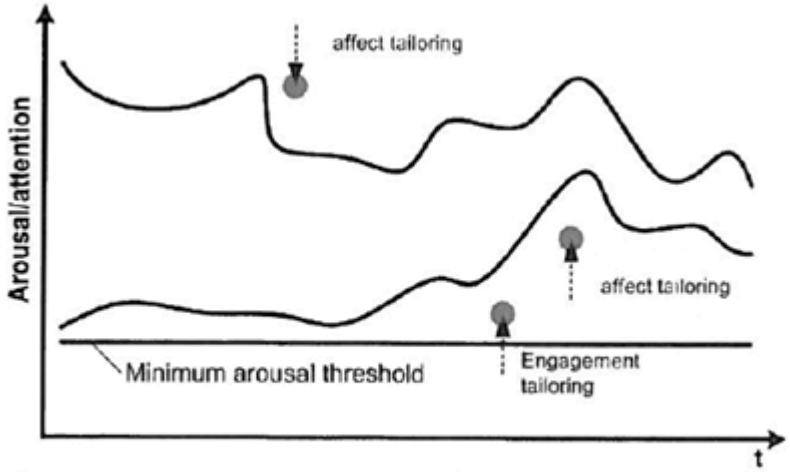


Assess → Model → Predict → Adapt → Influence Learning

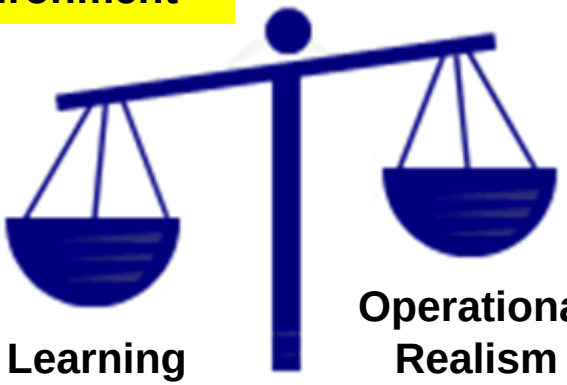
Cognition and Affect in Tutoring



Assessing cognition & affect during training is critical to adapting the instruction to meet the learning needs of the trainee while maintaining stressors represented in the operational environment



Vygotsky, L.S. (1978). Mind in Society: The development of higher psychological processes. Cambridge, MA: Harvard University Press.



Bjork, R. A. (1994). Memory and metamemory considerations in the training of human beings. In J. Metcalfe and A. Shimamura (Eds.), *Metacognition: Knowing about knowing* (pp. 185–205). Cambridge, MA: MIT Press.

Research in Computer-Based Tutoring

- three broad areas of research
  - student modeling
  - authoring and expert modeling
  - instructional strategy selection

Student Modeling

- **capabilities**
  - **tutors must be able to sense and interpret student behaviors and physiology to classify the student's affective and cognitive states**
  - **sensors must be passive/unobtrusive, portable**
  - **classification methods must be near real-time**
  - **classification methods must be accurate**

- **research questions**
  - **Which student behaviors and physiological measures are critical to predicting their affective and cognitive states?**
  - **What is the minimal set of sensors to predict student affect and cognition?**
  - **What classification methods are most accurate?**

Authoring Tools & Expert Model Development

- **capabilities**
  - **tutors should be modular to promote flexibility, extensibility, evaluation and reuse**
  - **methods are needed to automatically capture and rapidly model the behaviors and cognitive processes of experts and misconceptions of novices**
  - **methods are needed to evaluate the influence of variables of interest (sensors, instructional strategies)**

- **research questions**
  - **which methods for task analysis are most accurate, least obtrusive and most efficient?**
  - **which methods are optimal for team training?**

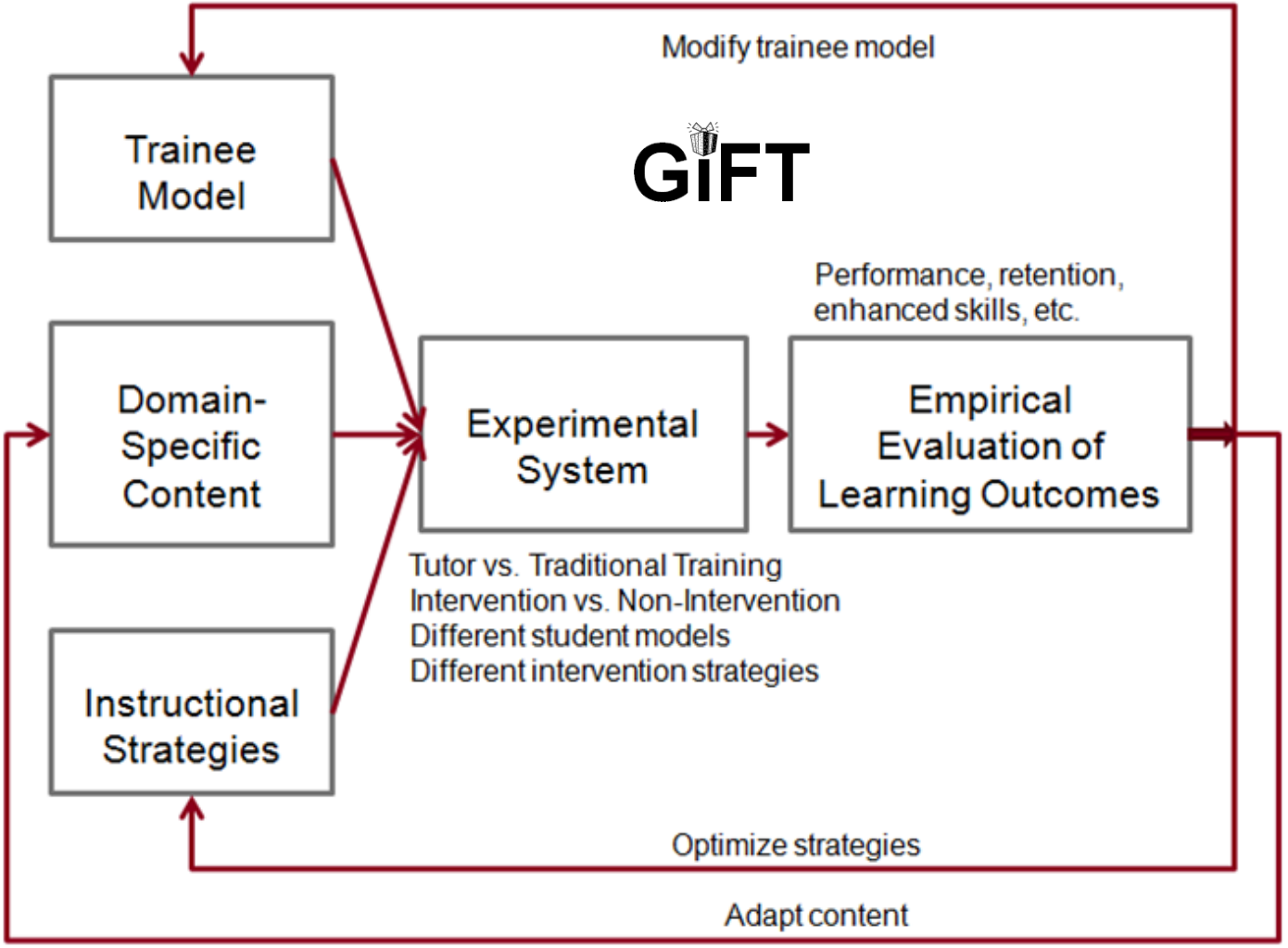
Generalized Intelligent Framework for Tutors (GIFT) Methodology

Assess → Model → Predict → Adapt → Influence Learning

understand individual trainee learning needs

make tutors & models easy to create and use

use trainee state & learning context to select appropriate strategies



Methodology derived from:

Hanks, S., Pollack, M.E. and Cohen, P.R. (1993). Benchmarks, Test Beds, Controlled Experimentation, and the Design of Agent Architectures. AI Magazine Volume 14 Number 4.

Instructional Strategy Selection

- **capabilities**
  - **instructional flow and challenge level adapted to the needs/states/traits of the student**
  - **feedback and tutor-student interaction modeled on the best human tutors**

- **research questions**
  - **Based on the student's affective and cognitive state, which instructional strategies are optimal?**
  - **Which strategies are domain-independent?**
  - **Is the effectiveness of strategies influenced by culture, values or other factors?**

Assessing the capabilities of tutors… standards

- adapt to the learner **better** than a human tutor
- enable learning **better** than a human tutor
- **fully perceive** learner behaviors and physiology through **remote** sensing
- support fully **mobile** training
- are **consistently accurate** (near 100%) in classifying the learner's cognitive state in near real-time
- have an **optimized repertoire** of instructional strategies
- are **automatically integrated** with a variety of training platforms (e.g., serious games, commercial/military training simulations).

Sottilare, R. and Gilbert, S. (2011). Considerations for tutoring, cognitive modeling, authoring and interaction design in serious games. Authoring Simulation and Game-based Intelligent Tutoring workshop at the *Artificial Intelligence in Education Conference (AIED) 2011*, Auckland, New Zealand, June 2011.

Bronze Tutor 

Silver Tutor 

Gold Tutor 

Platinum Tutor 

Recommendations for Future Research

- **Pedagogy - the relationship between student performance and states, and the effectiveness of the instructional method selected**

- **Individual differences – the influence of individual differences in instructional strategy selection**

- **Accelerated learning and retention – the influence of computer-based tutor actions on accelerating learning and facilitating retention**

- **Five general areas for research - analysis, diagnosis, prescription, mental model mismatch (misconceptions) and demonstration**

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Want to know more?

- **A Roadmap for Education Technology …**
  - **http://www.cra.org/ccc/docs/groe/GROE%20Roadmap%20for%20Education%20Technology%20Final%20Report.pdf**
  - **or Google "Roadmap for Education Technology"**
- **Listen to the papers that follow**
  - **Keith – clustering methods to determine trainee state**
  - **Elaine – reflection in trainee models**
  - **Heather – human-computer action in tutors**

Questions?

Domande?