Technology-based Training

Art Graesser

Psychology, Computer Science, & Institute for Intelligent Systems

Funding: National Science Foundation, Office of Naval Research, Department of Defense, & Institute for Education Sciences

FedEx Institute of Technology, The University of Memphis

THE UNIVERSITY OF MEMPHIS

Institute for Intelligent Systems

Department of Defense

NSF

Department of the Navy, ONR, Science & Technology

IES Institute of Education Sciences

Overview

- Introductory comments
- 10 genres of learning environments
- Recommended funding priorities

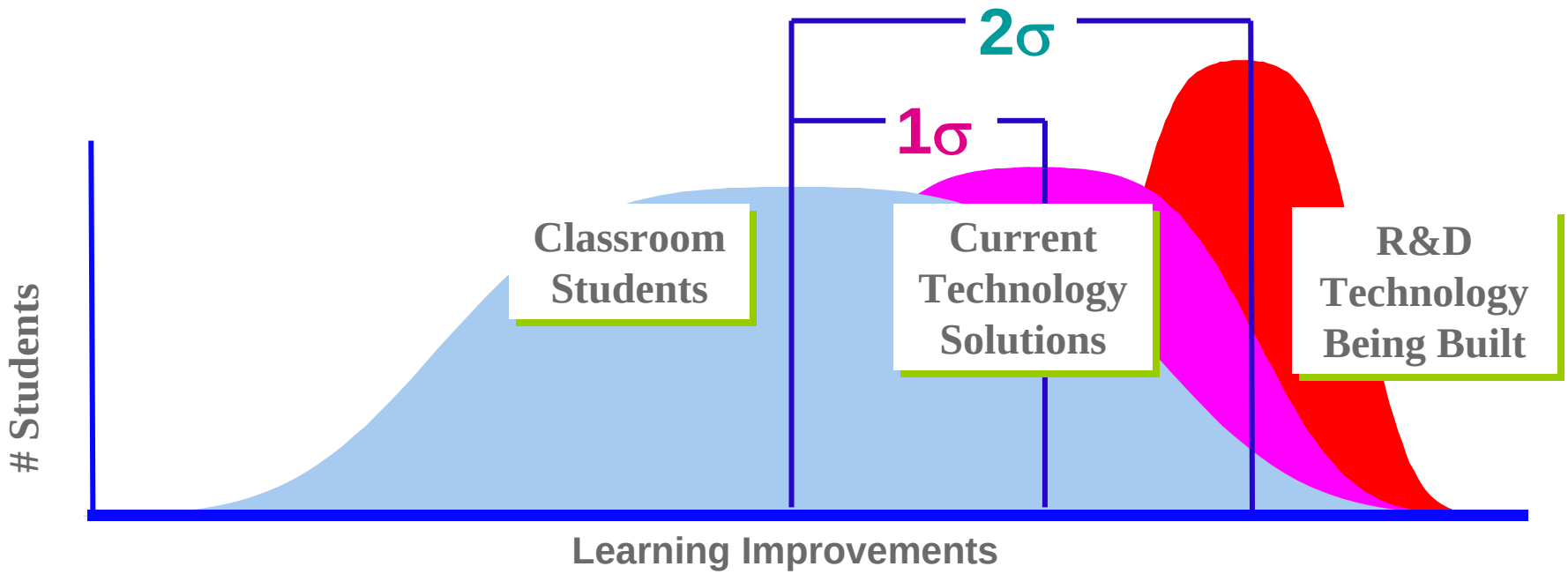
Introductory comments

- **Learning technologies are only as good as the underlying pedagogy (Bransford, Clark, Cuban, nearly everyone)**
- **Advanced Distributed Learning initiative (www.adlnet.org)**
  - **Fortify learning environments with science and good engineering**
  - **SCORM standards to make content sharable, reusable, interoperable, extendable**
  - **Cutting costs by standards and repositories**
- **Growth of learning sciences in different funding agencies**

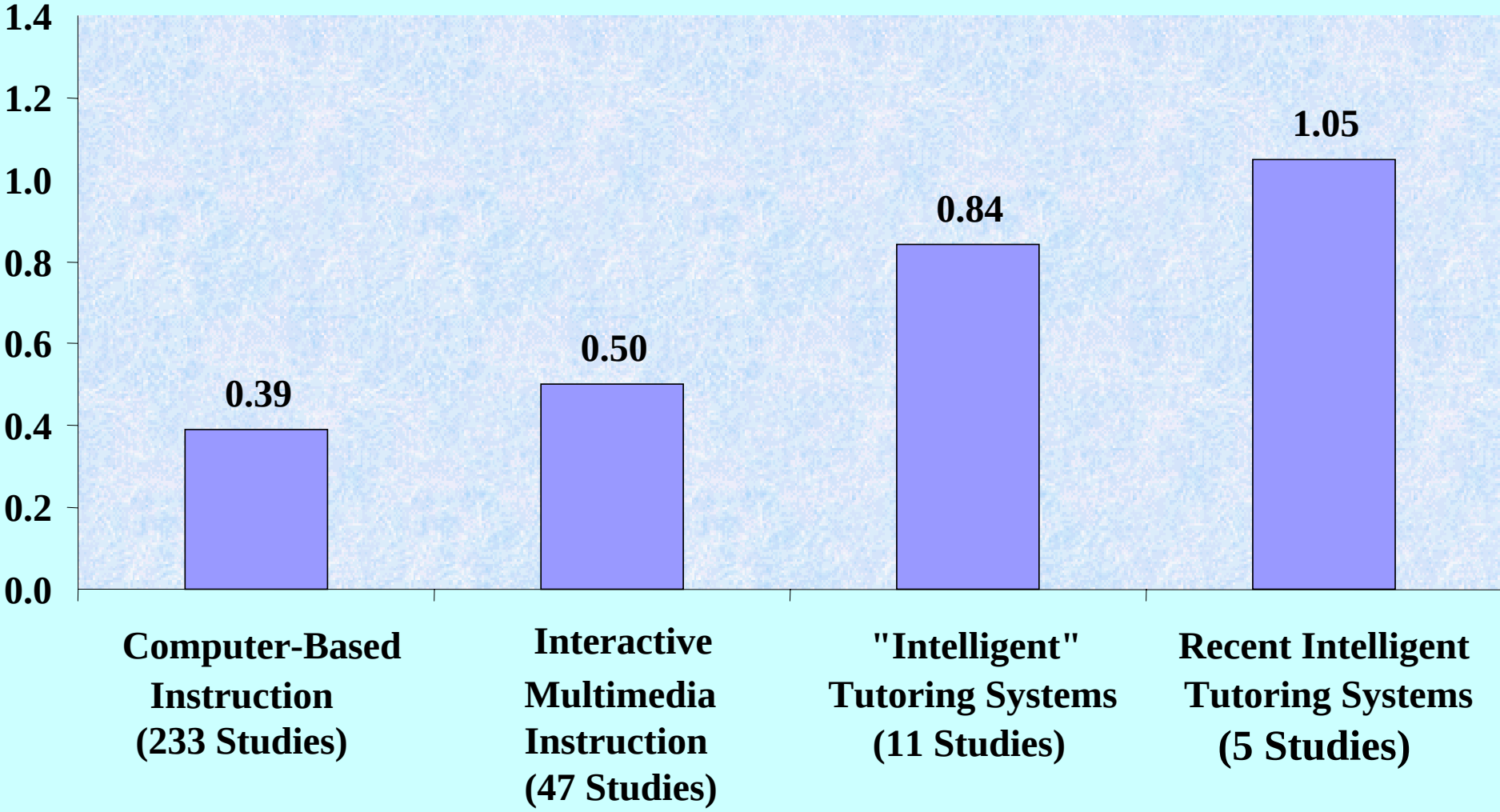
INSTITUTE for INTELLIGENT SYSTEMS

How much learning improvement?

2 sigma goal (Bloom, 1984)
Average tutored student's achievement will be better than 98% of classroom students

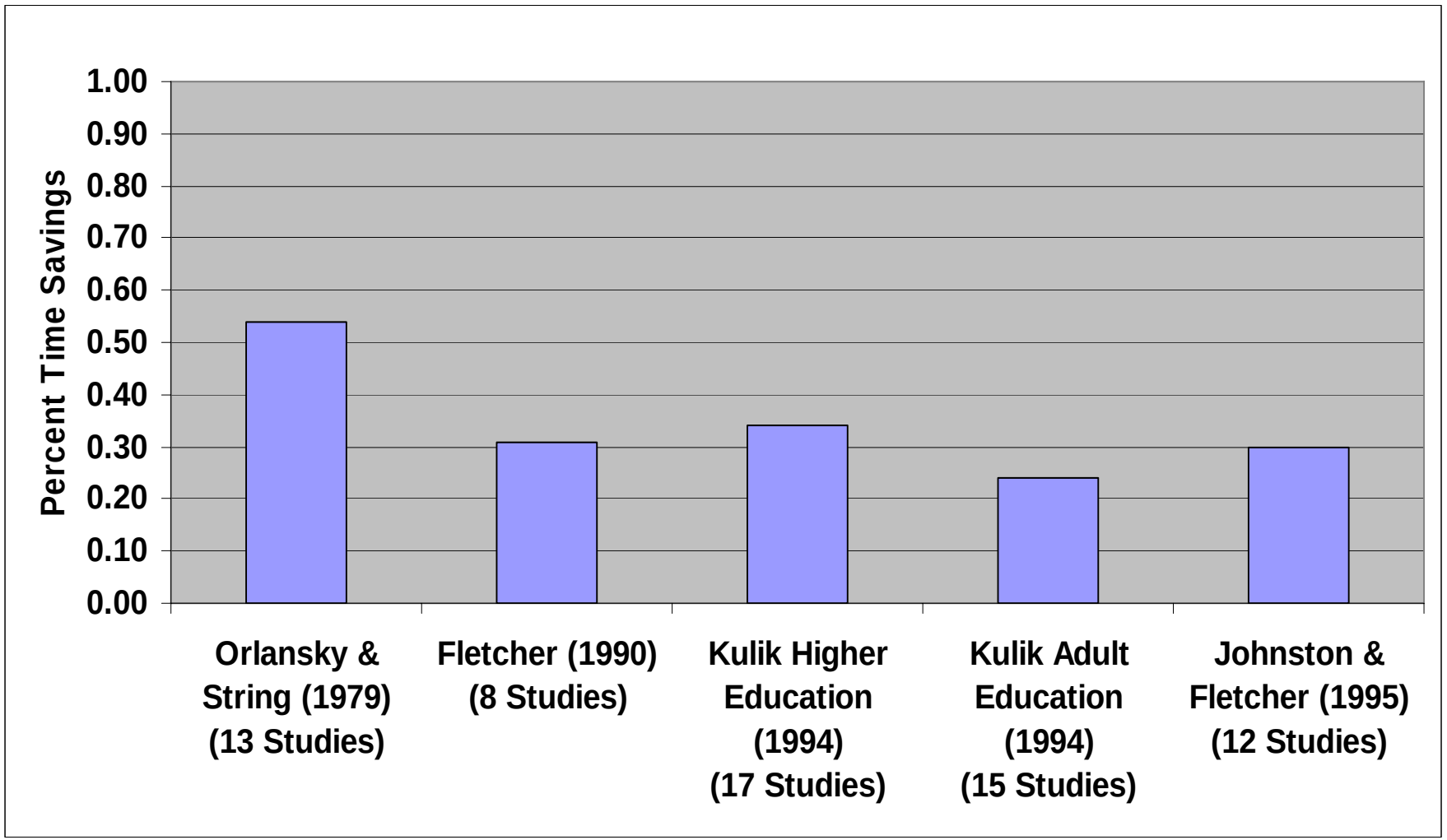


Learning Gains of Technology-based Instruction (*Dodds & Fletcher, 2004; Wisher & Fletcher, 2004*)



**Measured in Standard Deviations*

Percent Time Savings from Technology-Based Instruction



Costs and ROI's

- **$10,000** — **10 hours of CBT**
- **$100,000** — **Course with multimedia**
- **$1,000,000** — **Hypertext/hypermedia**
- **$10,000,000** — **Intelligent tutoring system**
- **$100,000,000** — **Serious multiparty game**

INSTITUTE for INTELLIGENT SYSTEMS

Characteristics of learners that we wish were better

- Distributing their learning over time
- Focus on deep rather than shallow knowledge
- Tolerance for boring learning material
- Self-regulated learning, monitoring, & and error correction
  - Learners need modeling, scaffolding, & guidance
- Learner question asking
- Comprehension calibration
- Precise articulation of knowledge

Pedagogical strategies *rarely* used by typical human tutors and learning environments

- Socratic tutoring (*Collins, Stevens*)
- Modeling-scaffolding-fading (*Rogoff, Gardner*)
- Reciprocal training (*Brown, Palincsar*)
- Anchored Learning (*Bransford,CTGV*)
- Situated learning (*Greeno, Lave, Wender*)
- Embodied learning (*Glenberg, Nathan*)
- Error diagnosis & repair (*VanLehn, Lesgold*)
- Building on prerequisites (*Gagne*)
- Sophisticated motivational techniques (*Lepper*)

INSTITUTE for INTELLIGENT SYSTEMS

Principles of deep learning in respectable learning environments

1. Active construction of meaning
2. Explanation
3. Coherence & connections
4. User modeling & adaptive responding
5. Interactive simulation
6. Dialog scaffolding
7. Inquiry through question asking & answering
8. Cognitive disequilibrium
9. Cases & scenarios
10. Metacognitive strategies
11. Overlearning & automaticity
12. Conscious deliberation & reflection

TMGL Landscape

- **T**echnologies
- **M**echanisms of pedagogy and psychology
- **G**oals of learning environment
- **L**earner characteristics

Genres of Learning Environments

- Computer-based training
- Multimedia
- Interactive simulation
- Hypertext and hypermedia
- Intelligent Tutoring Systems
- Inquiry-based information retrieval
- Animated pedagogical agents
- Virtual environments with agents
- Serious games
- Computer supported collaborative learning

Intelligent Tutoring Systems

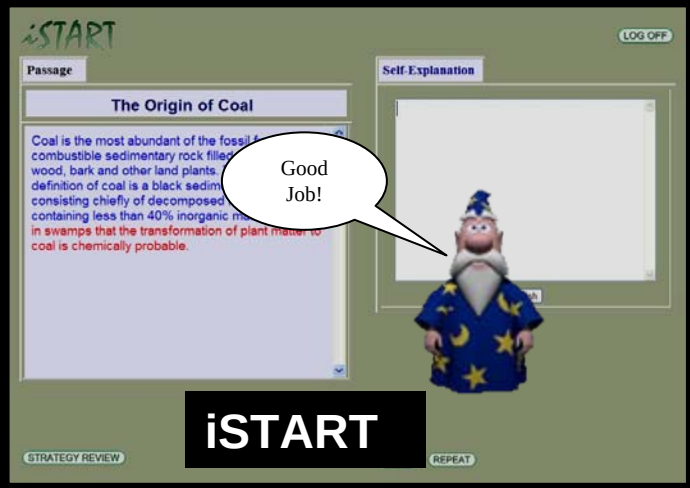
- **SOPHIE** (Brown) -- electronic circuits
- **GUIDON** (Clancy) -- medicine
- **WHY** (Stevens,Collins) -- meteorology
- **PACT** (Anderson, Corbett, Koedinger) algebra, geometry, computer languages
- **SHERLOCK** (Lesgold) -- basic electronics and devices
- **ANDES** (VanLehn) – physics
- **DIAGNOSER** (Hunt, Minstrell) -- physics
- **Intelligent Essay Assessor** (Landauer, Foltz) – writing
- **AutoTutor** (Graesser) – physics, computer literacy, critical thinking

INSTITUTE for INTELLIGENT SYSTEMS

Exploring a Sea of Animated Conversational Agents

Virtual Realities, Interactive Simulation, & Serious Games

AutoTutor



iSTART

Systems at University of Memphis and USC


Virtual Classroom

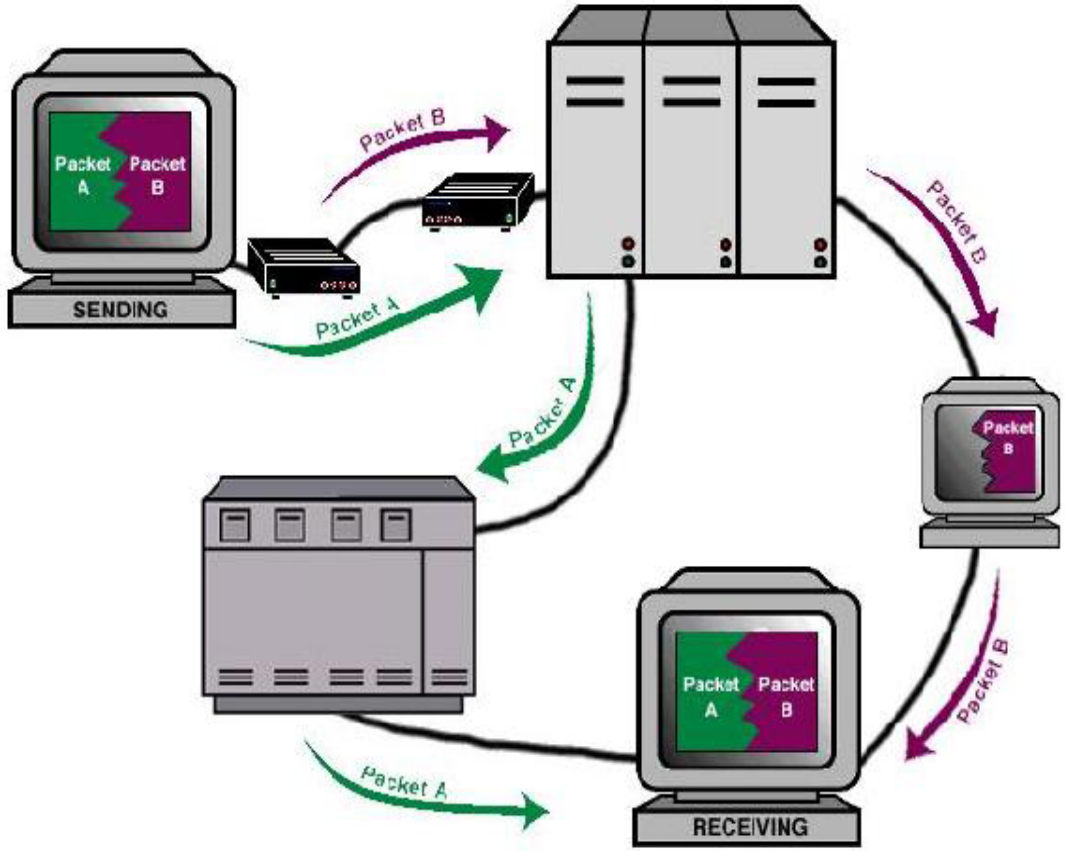

TLTS

Tactical Language Training System (Johnson)

Computer Literacy

Graesser, Lu, Jackson, Mitchell, Ventura, Olney, & Louwerse (2004)

How is the packet switching model of message transmission like the postal system?



Packets are sent to intermediate destinations before being routed to their final destination.

The sun exerts a gravitational force on the earth as the earth moves in its orbit around the sun . Does the earth pull equally on the sun? Explain why.

Talking head
- Gestures
- Synthesized speech

- Presentation of the **question/problem**

Log of previous turns

moves in its orbit around the sun . Does the earth pull equally on the sun? Explain why.
Student:

Tutor: Is there anything you can add to this?
Student:

Tutor: Kind of.
Tutor:
Tutor: How does Newton's law of motion apply to this situation?
Tutor:

Type your response here:

Submit

Settings...

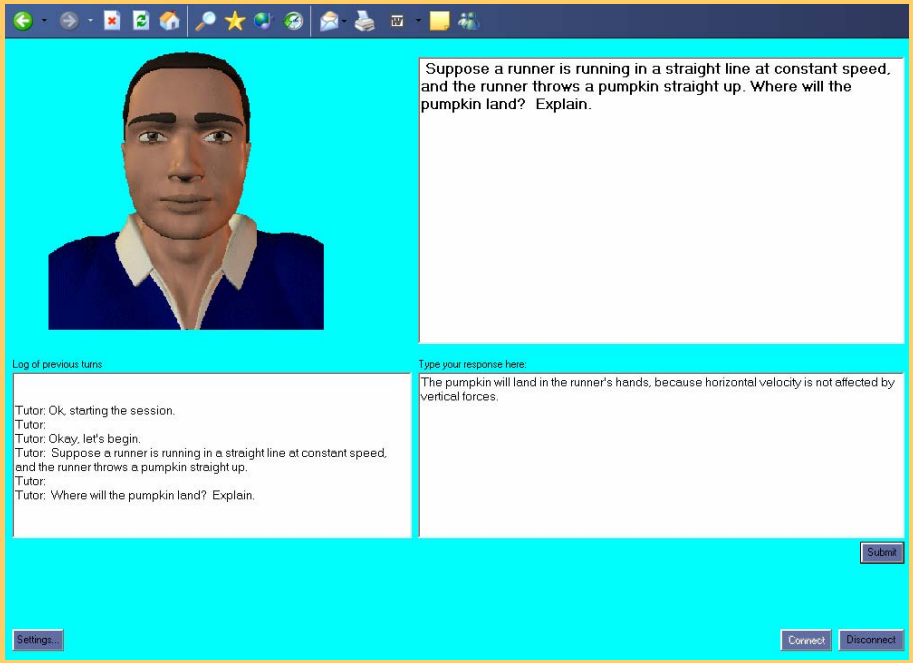
Dialog history with
- tutor turns
- student turns

Student input (answers, comments, questions)

Conceptual Physics
(VanLehn, Graesser, et al., 2007)

Three tutoring conditions

- AutoTutor
- Read textbook
- Read nothing



Example Multiple Choice Test Item (similar to Force Concept Inventory)

As a truck moves along the highway at constant speed, a nut falls from a tree and smashes into the truck's windshield. If the truck exerts a 1,000 N force on the nut, what is the magnitude of the force that the nut exerts on the truck?

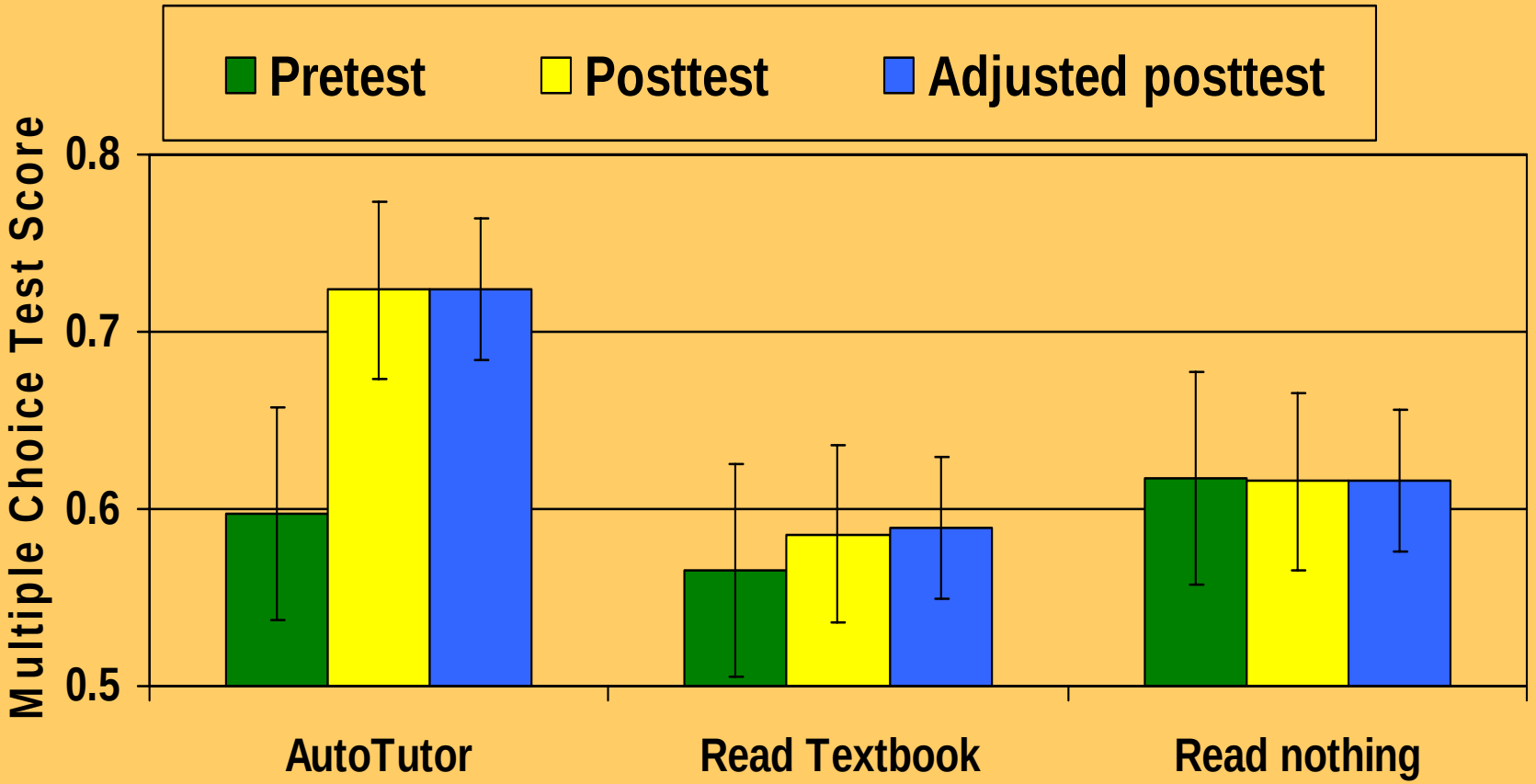
a) **1,000 N**

b) **less than 1,000 N**

c) **N (the nut does not exert a force on the truck)**

d) **greater than 1,000 N (because the nut hit the truck, it exerts a greater force on the truck than the truck exerts on the nut)**

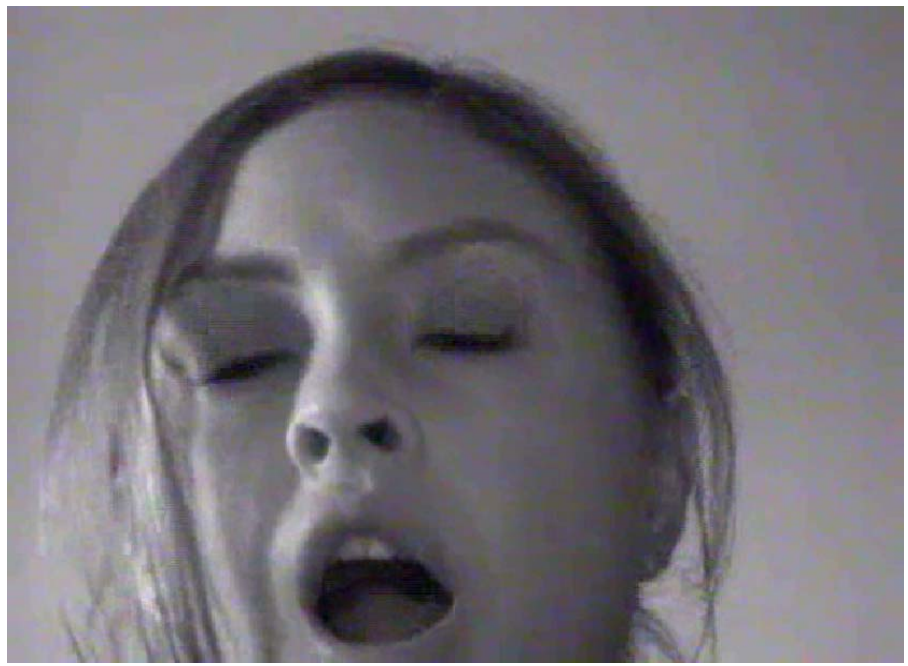
Multiple Choice Test on Physics



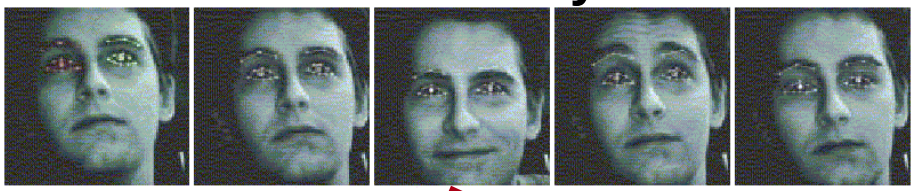
Affective States

(Graesser, Craig, D'Mello, Picard's Affect Computer Lab at MIT)

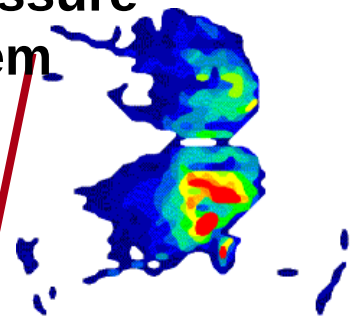
- Confusion
- Frustration
- Boredom
- Flow
- Delight
- Surprise



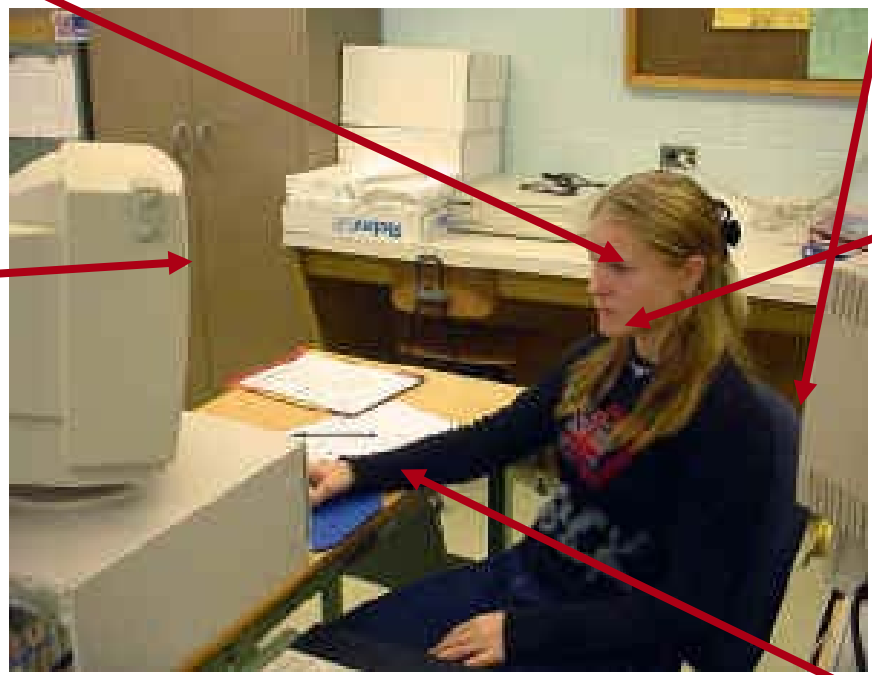
Visual – IBM Blue eyes camera



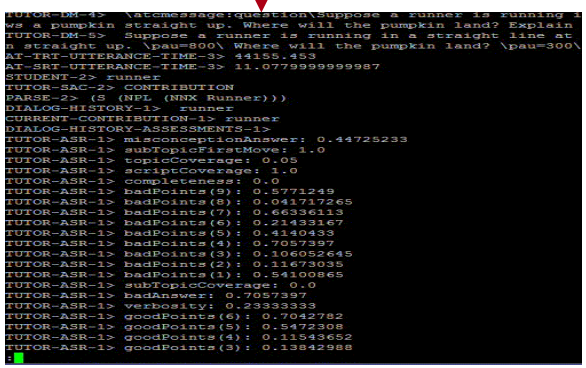
Posture – Body Pressure Measurement System



AutoTutor



Speech intonation also



AutoTutor text dialog

Pressure – force sensitive mouse and keyboard

How might AutoTutor be responsive to the learner's affect states?

1) If learner is **frustrated**, then AutoTutor gives a hint.
2) If **bored**, then some engaging razzle dazzle
3) If **flow/absorbed**, then lay low
4) If **confused**, then intelligently manage optimal confusion

Recommended Funding Priorities

1) **Blended instruction that assigns optimal learning environments to a particular learner at the right time.**

INSTITUTE for INTELLIGENT SYSTEMS

Ideal Vision

electronic Personal Advisor for Learning

24x7 Dialog as Tutor & Mentor

- Animated conversational agent
- Intelligent human-computer interface
- Intelligent sensing

Maintains Learner Profile

- Demographic data
- Subject matter knowledge
- Performance on tests
- Cognitive/metacognitive abilities
- Motivation and emotion
- Personality traits
- Dialog history

Large Courseware Repository

- Computer-based training
- Multimedia
- Interactive simulation
- Intelligent tutoring systems
- Games
- etc.

Intelligent Action Selection

- Next learning environment
- Next problem to work on
- Next dialogue act:
  - Suggestion, hint
  - Question
- Distributed over time

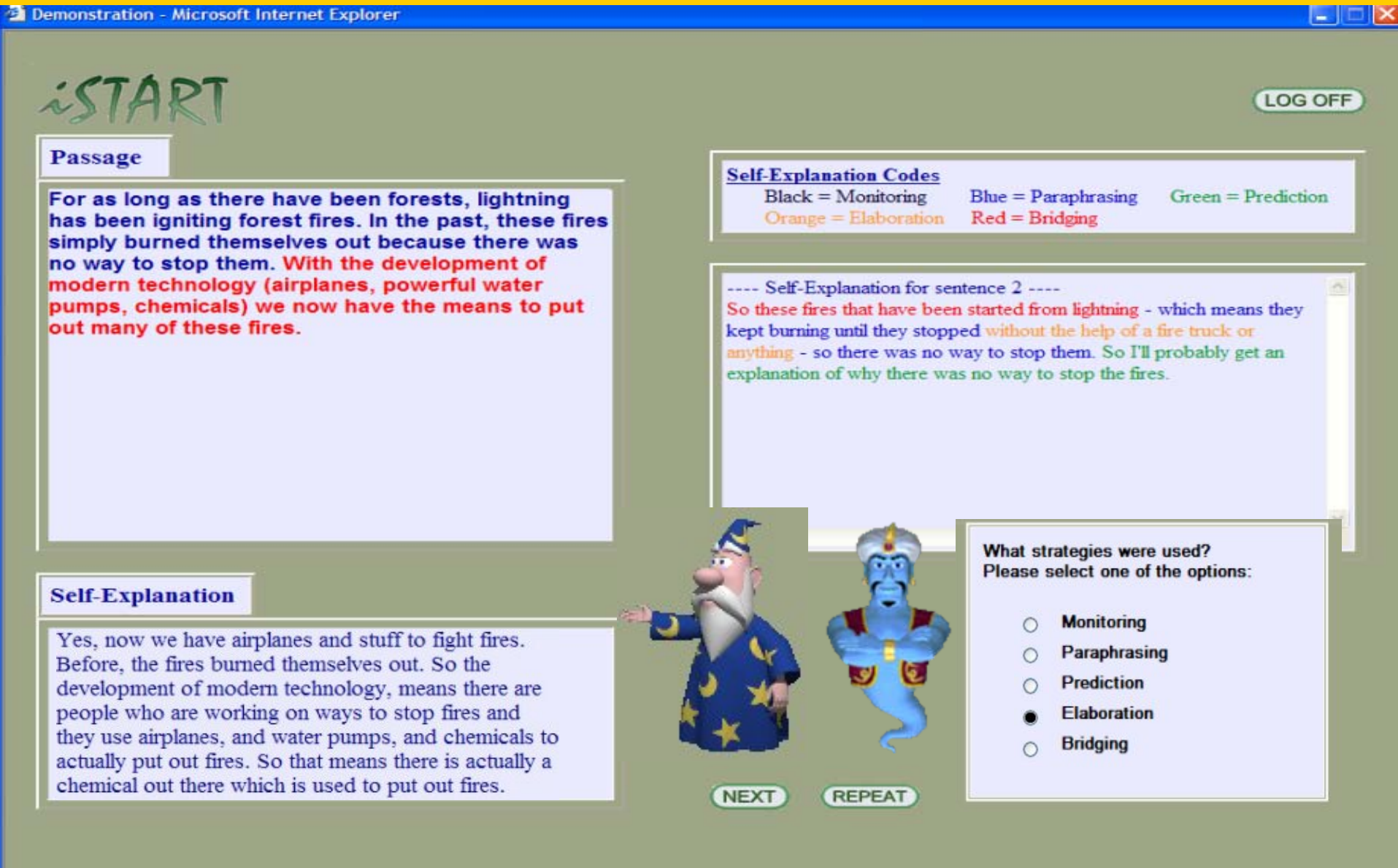
Recommended Funding Priorities

2) **Agents that model and scaffold the use of complex learning environments and human-computer interfaces**

INSTITUTE for INTELLIGENT SYSTEMS

McNamara's iSTART

Interactive Strategy Training for Active Reading and Thinking



iSTART Modules

- **Introduction Module**
  - Teacher-Agent and 2 Student Agents discuss reading strategies
  - Quiz after each strategy
  - Mini-Demonstration after first 3 strategies
- **Demonstration Module**
  - Genie self-explains a text
  - Merlin provides feedback
  - Trainee is asked to identify strategies
- **Practice Module**
  - Trainee types self-explanations to science text
  - Merlin guides the trainee and provides feedback

INSTITUTE for INTELLIGENT SYSTEMS

Recommended Funding Priorities

3) **Modeling and testing the conditions in which interactive simulation with multimedia promotes deep learning**

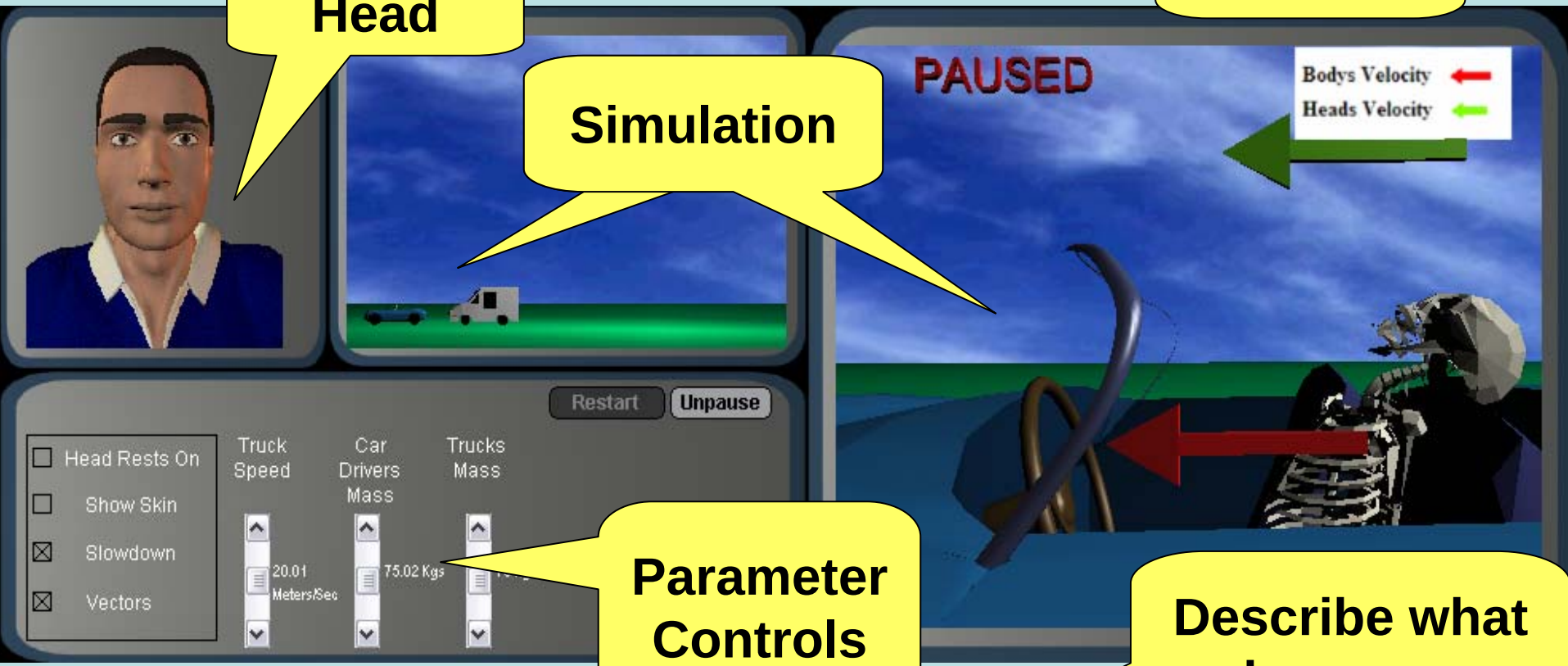
INSTITUTE for INTELLIGENT SYSTEMS

When a car without headrests on the seats is struck from behind, the passengers often suffer neck injuries. Why do passengers get neck injuries in this situation?

Question

Head

Simulation



Parameter Controls

Describe what happens

Recommended Funding Priorities

4) **Systematic tests of the impact of serious games on learning.**

Recommended Funding Priorities

5) **Examining the process of authoring advanced learning environments.**

INSTITUTE for INTELLIGENT SYSTEMS

Recommended Funding Priorities

1) **Blended instruction that assigns optimal learning environments to a particular learner at the right time.**
2) **Agents that model and scaffold the use of complex learning environments and human-computer interfaces.**
3) **Modeling and testing the conditions in which interactive simulation with multimedia promotes deep learning.**
4) **Systematic tests of the impact of serious games on learning.**
5) **Examining the process of authoring advanced learning environments.**

Fishics AutoTutor

Andrew Olney

How does AutoTutor compare to comparison conditions on tests of deep comprehension?

- **0.80** compared to pretest, doing nothing, and reading the textbook
- **0.22** compared to reading relevant textbook segments
- **0.07** compared to reading succinct script
- **0.13** compared to AutoTutor delivering speech acts in print
- **0.08** compared to humans in computer-mediated conversation
- **-0.20** compared to AutoTutor enhanced with interactive 3D simulation

Challenges of generalization

- Classic Hayes and Simon study on problem isomorphs
- Important role of surface features, versus the more relevant deep relational constructs (Chi, Gentner, Forbus)
- A 1-2 hour intervention is rarely effective, versus distributed training on a large number of diverse cases
- Situated context often frames, compartmentalizes, and constrains
  - Life never announces the relevant chapter to study
  - Formal versus informal environments
  - Broken dishwasher anecdote

Conclusions

- **Advanced learning technologies can be used to manipulate characteristics and parameters of complex learning environments that resemble everyday experiences.**
- **We can measure impact of these environments on measures that vary in grain size.**
- **The impact of these learning environments on learning is adequately documented and either impressive or promising.**
  - **except for games and VR – where there are few studies.**
- **The jury is still out on matters of generalization.**

Landscape of Learning Traditions and Paradigms

Psychology

Associationism
Classical conditioning
Operant conditioning
Modeling
Verbal learning and memory
Developmental theories

Education

Advanced organizers
Model-scaffold-fade
Inquiry learning
Problem-based curriculum
Apprenticeship learning
Self-regulated learning

Machine learning

Category induction
Connectionism
Case-based
Explanation-based
Bayesian and other statistical
Genetic algorithms

Computer learning environments

Computer-based instruction
Intelligent tutoring systems
Hypertext-hypermedia-web
Multimedia and virtual reality
Interactive simulation
Games

Analysis of Tutorial Dialogue Patterns

- **Unskilled human tutors**
  - **Most tutors are unskilled: Cross-aged, paraprofessions, peers**
  - **Unskilled tutors are very effective (Cohen, Kulik, & Kulik, 1982)**
  - **100 hours of video transcribed and analyzed (Graesser & Person, 1994; Graesser, Person & Magliano, 1995)**
- **Accomplished human tutors no doubt do better**
  - **Studies by Bloom, Chi, Collins, Derry, Evens, Fox, McArthur, Norman**
  - **New ONR project by Person**

Affective States

- **Confusion**
  - a noticeable lack of understanding
- **Frustration**
  - dissatisfaction or annoyance
- **Boredom**
  - being weary or restless through lack of understanding
- **Flow**
  - state of interest that results from involvement in an activity
- **Delight**
  - a high degree of satisfaction
- **Surprise**
  - wonder or amazement, especially from the unexpected
- **Neutral**
  - no apparent emotion or feelings