METALS

Masters of Educational Technology & Applied Learning Science

Learn. Create. Innovate.

Virtual Open House

October 15 @ 9 AM EDT

Applications Due December 10th

http://metals.hcii.cmu.edu

Welcome!

- Ken Koedinger, Director

- Michael Bett, Managing Director

Extended Welcome from Our Learning Science Faculty


Vincent Aleven


Justine Cassell


Sharon Carver


Jessica Hammer


Erik Harpstead


Lauren Herckis


Ken Koedinger


Chinmay Kulkarni


Marti Louw


Marsha Lovett


Bruce McLaren

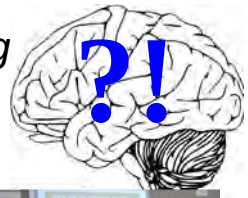

Amy Ogan


Carolyn Rose


John Stamper

Science & technology of learning:
important, interesting, challenging!!

- Education is *important*
- Unlocking the mysteries of human learning is *interesting*
- Tech innovation is *challenging, fun, powerful*




Intelligent tutors helping city kids catch up in math


Learning games on mobiles in Africa


Virtual labs & MOOCs scaling education

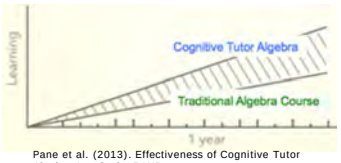

Intelligent exhibits make doing science fun!

Overview

- **CMU & METALS are unique**
- Curriculum
  - Capstone
  - Courses
- Finances
- Application

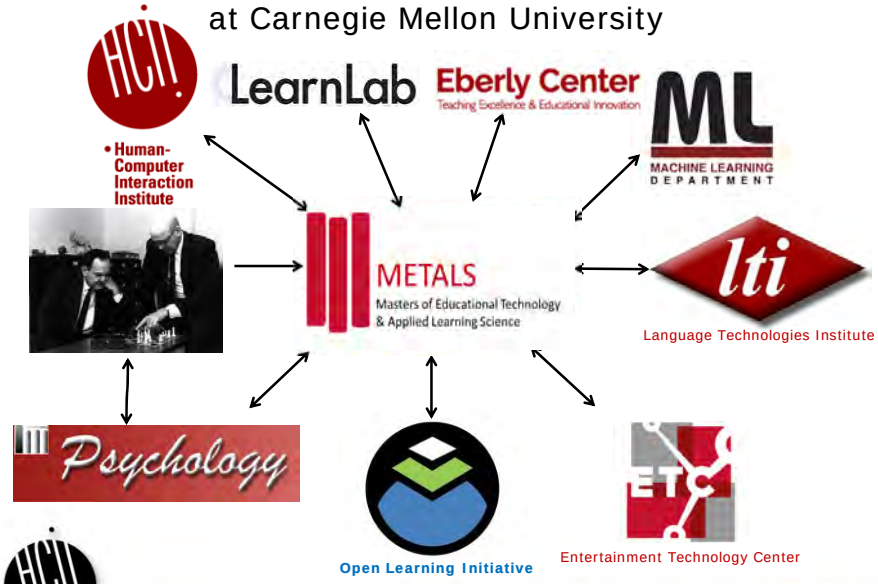
CMU Learning Science is Making a Difference

- Real-world impact of Cognitive Tutors
  - 600K students/year
  - *Doubles achievement!*
  - 2011 sale for ~$95M
- OLI college courses
  - 30+ open online courses
  - *2x faster & better*



Pane et al. (2013). Effectiveness of Cognitive Tutor Algebra I at Scale. RAND.

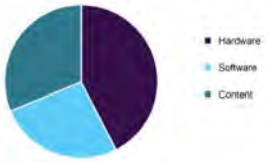
Learning Science & Technology Ecosystem at Carnegie Mellon University



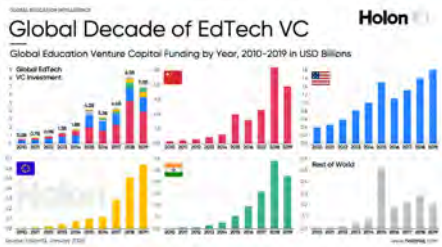
Learning & Training Continues to Boom!!

- *New ideas*
- *New technologies*
- *New companies*
- *New careers*

Spending by area



Edtech Market Projected to triple



The Edcation Market is Huge!

- 1.5 Billion K12 Students**
- 151 Million Post-Secondary Students**
- Education World market: $6 Trillion*
- EdTech World Market $152 Billion projected to grow to $342B by 2025*
- Venture Captial: $8.2 Billion*

*https://www.holoniq.com/edtech/10-charts-that-explain-the-global-education-technology-market/

**http://data.uis.unesco.org/# (2015 data)

Many Spinoffs and Local Companies

Many Corporate Partners

Carnegie Mellon is Unique

Our Values… Innovative, Inspiring, Influential, Quality, Interdisciplinary, Business, Relevant, Impactful

Our Methods… cutting edge, grounded in theory, drawn from industry

Our Research…collaborative

Our Projects… practical and experiential

Overview

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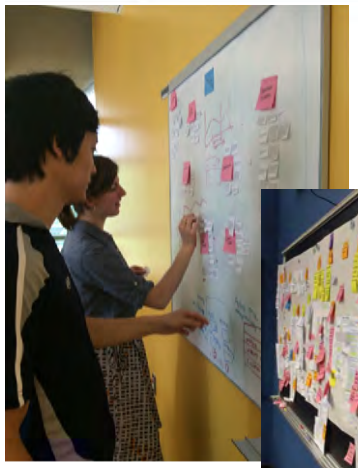
Major Focus: Capstone Project

- Apply METALS skills on a two semester-long project
- Integrate skills gathered over the curriculum
- Be a member of an interdisciplinary teams (4-6 people)
- For an external client
- Learn to interview (CTA), research, write reports & give presentations
- Produce a high fidelity prototype

Learn to Create Evidence-Based Innovations in Learning

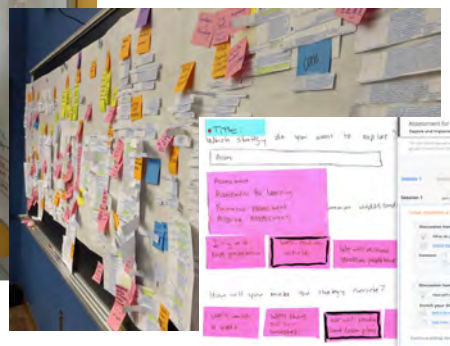
Gather Field Data

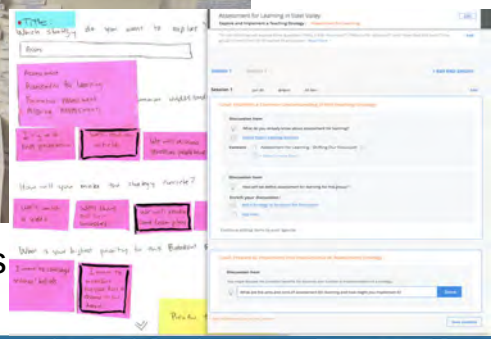
Review Literature



Understand Needs

Understand Research





Create Effective Designs

...And design some more. Then do it all over again, but better!

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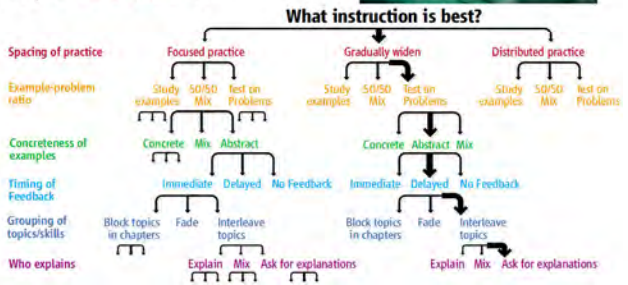
METALS Core Courses

- **E-Learning Design Principles & Methods**
- **Educational Goals, Instruction and Assessment**
- **Interaction Design Overview**
- **Tools for Online Learning**
- **Capstone Project**

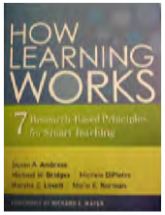
E-Learning Design Principles & Methods

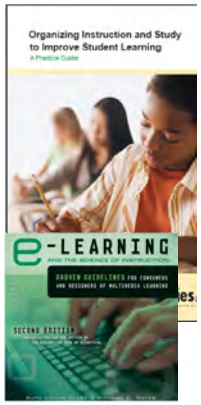
- Gain a *broad understanding* of the field and literature.
- Know when to apply *evidence & theory*
- Learn how to adapt *methods* to specific needs

Ken Koedinger
TA: Mimi McLaughlin



Understand the best form of instruction



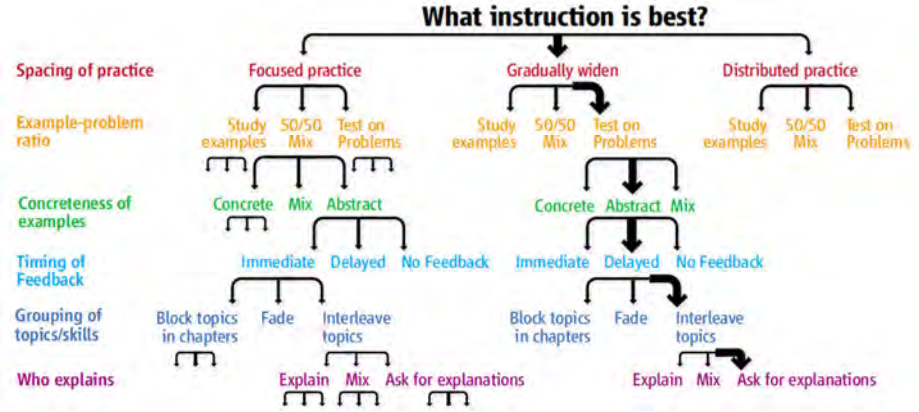


- More assistance vs. more challenge
  - Basics vs. understanding
  - Education wars in reading, math, science…
- Researchers like binary oppositions too. We just produce a lot more of them!
  - Massed vs. ***distributed*** (Pashler)
  - Study vs. ***test*** (Roediger)
  - ***Examples*** vs. problem solving (Sweller …)
  - ***Direct instruction*** vs. discovery learning (Klahr)
  - Re-explain vs. ***ask for explanation*** (Chi, Renkl)
  - ***Immediate*** vs. ***delayed*** (Anderson vs. Bjork)
  - ***Concrete*** vs. ***abstract*** (Pavio vs. Kaminski)
  - …

Koedinger, K. R., & Aleven, V. (2007). Exploring the assistance dilemma in experiments with cognitive tutors. *Educational Psychology Review, 19*(3), 239-264.

Instructional Complexity
How many instructional options are there?

More help, *passive* ⟷ More challenge, *active*



Many other dimensions of choice: animations vs. diagrams vs. not, audio vs. text vs. both, …

$>3^{15*2}$ = 205 trillion options!

Koedinger, Booth, Klahr (2013). Instructional Complexity and the Science to Constrain It. *Science*.

What instructional choices are best for a particular course?

- Choices depend on a deep understanding of the content
  - A "cognitive model"
- But, do course designers know what they know?

Creating Cognitive Models is not Obvious

Which is hardest for algebra students?

Story Problem

As a waiter, Ted gets $6 per hour. One night he made $66 in tips and earned a total of $81.90. How many hours did Ted work?

Word Problem

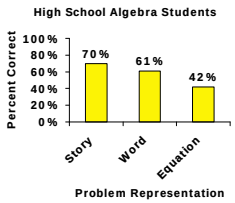
Starting with some number, if I multiply it by 6 and then add 66, I get 81.90. What number did I start with?

Equation

x * 6 + 66 = 81.90

Math educators say: story or word is hardest

Equations are hardest for students…



Expert blind spot!
Experts do not know what they know: They are incorrectly think equations are easy for students

Educational Goals, Instruction, and Assessment

Students will learn to use scientifically-based principles & practical strategies for:

- developing learner models & educational goals based on analysis of the knowledge, skills, and dispositions required for understanding and mastery
- aligning the instructional program and its valid assessment with learners and goals
- considering additional aspects of learning environments that may impact implementation and evaluation

Reading, and Seminar Discussion



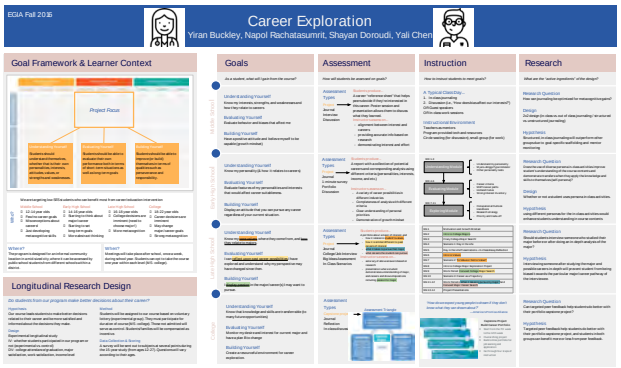
Figuring Out How this All Works…


Course Project

Actually Apply Course Big Ideas

1. Context & Initial Resources
2. Anticipated Learner Profile
3. Learning Goal Specification
4. Assessment Design
5. Instructional Design
6. Research Design

Final Presentation & Poster



Poster Session

Tools For Online Learning

- This course is expected to give you
  - an overview of current educational technology.
  - hands on experience with educational technology used in online learning
- Hands on projects every couple of weeks
- Final project build out a complete course module

Topics Include

- Overview of Educational Technology
- Learning Management Systems
- Accessibility
- Adaptive Learning
- Conversational Agents
- Data-Driven Design and Development
- Online Courseware

Example Elective Courses

Technology	Learning Science	Design
Personalized Online Learning	Cognitive Development	Human Factors
Design of Educational Games	Human Expertise	Stats: Experimental Design for Behavioral and Social Sciences
Applied Machine Learning	Applications of Cognitive Science	Design of Educational Games
Computational Models of Discourse Analysis	Research Methods for the Learning Sciences	Service Design Social Perspectives in HCI
Design & Engineering of Intelligent Information Systems	Role of Technology in Learning in the 21st Century	Computer Science Perspectives In HCI
Role of Technology in Learning in the 21st Century	Scientific Research in Education	Research Methods in Human Centered Design
The Big Data Pipeline	Learning Analytics and Educational Data Science	Learning Media Design
Mobile Service Innovation		Learner Experience Design

General Electives Continued

- Crowd Programming
- Entrepreneurship
- Designing for Service
- Web Accessibility
- Gadgets, Sensors and Activity Recognition in HCI
- Machine Learning Text Mining
- Advanced Web Design
- Designing Human Centered Software
- Social Perspectives in HCI
- Language and Statistics
- Decision Making Under Uncertainty

  - >100 others in other part of the university, if approved
    - Business, CFA, H&SS, CS, Robotics, Entertainment Technologies

We want students who are:

- Passionate about using technology to develop better learning outcomes
- With a wide variety of backgrounds including:
  - computer science
  - design
  - psychology
  - education
  - business
  - any educational content domain

On the Philosophy…

- METALS education provides students
  - Skills to engineer & implement innovative & effective educational solutions
  - Real-world project-based experience
  - Team management
- You will learn about all of software development, psychology, & design
  - You will not become an expert in all in 1 year
  - You will learn to communicate with specialists in other areas

What You Will Be Able to Do After METALS? Part 1

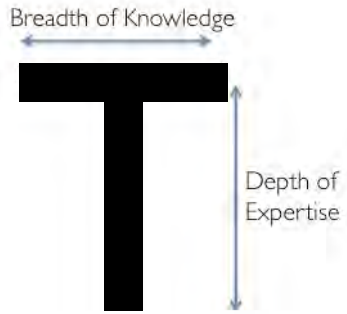
- Design, develop, & implement *innovative, effective, & desirable* educational solutions
- *Innovative*
  - Use state-of-the-art technologies
    AI, machine learning, language technologies, intelligent tutoring systems, mixed reality, …
- *Effective*
  - Apply cognitive & social psychology principles to instructional design, analysis, & redesign
  - Design & evaluate using cognitive task analysis, data mining, statistics, experimentation

What You Will Be Able to Do After METALS? Part 2

- *Desirable*
  - Design skills to enhance learning *and* enjoyment
- *Innovative*: Analytic, psychometric & educational data mining skills
- *Putting it together*: Develop continual improvement programs that employ experiments & analytics to reliably identify best practices & opportunities for change

Gain Breadth & Expertise

- You may already possess expertise in some of these areas, but not in all.
- METALS will
  - Deepen your prior expertise
  - Broaden your knowledge in new areas



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Finances

- 2020-2021
  - 3 Semesters (4 semester option available)
  - $23,855 per semester
  - ~$27,000 for living expenses
  - $100,000 commitment (for 3 semester option)
- 2021-2022 Tuition Not Set
- Currently offering small merit-based tuition assistance ($2000-$4000/semester)
  - Not guaranteed
  - If you are skilled & passionate, let us know!
- Scholarships – see METALS FAQ page
  - BiPOC and BLM scholarships (GEM) information forthcoming

Overview

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  - Capstone
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- **Application**

Application Guidelines

- Apply Online
  - https://applygrad.cs.cmu.edu/apply/index.php?domain=1
- Applications Due December 10th
- Applications Must Demonstrate
  - Your interest in EdTech and/or Learning Science
  - Past relevant experience/training
  - Plans after you graduate
- GRE optional but strongly encouraged/preferred
  - Expected 165 Quantitative, 160 Verbal
  - But we look at the entire application…
- English Proficiency is required!
  - TOEFL
    - 25 or better in 3 out of 4 sections and
    - 23 or better in speaking
  - DuoLingo English Test is a new option
  - IELTS

Questions?

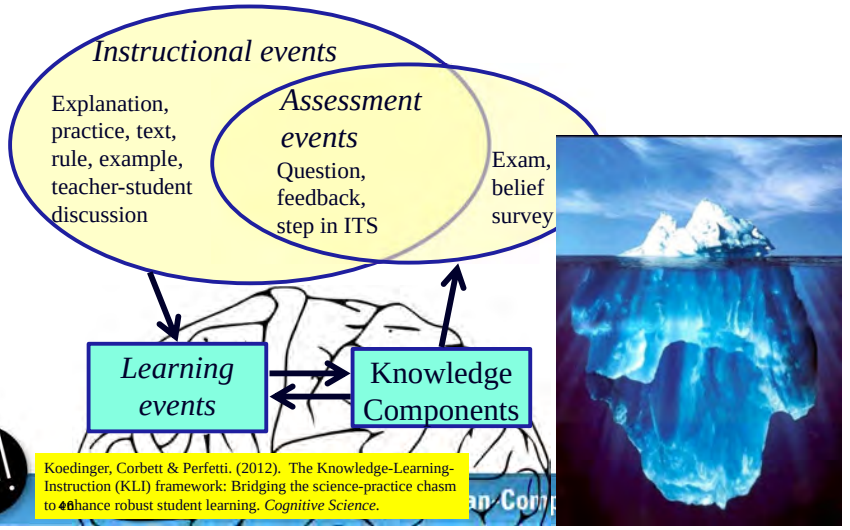
http://metals.hcii.cmu.edu

Applications Due December 12th

A bit about me, Ken Koedinger

- Modest educational background
  - Tech skills, want to make a difference
- Math ugrad, computer science masters, cognitive psychology phd => HCI
- Intelligent tutors for math
  - In city schools
  - Spin-off reaches millions
  - Doubles algebra achievement
- Direct LearnLab, formed METALS

Knowledge-Learning-Instruction Framework

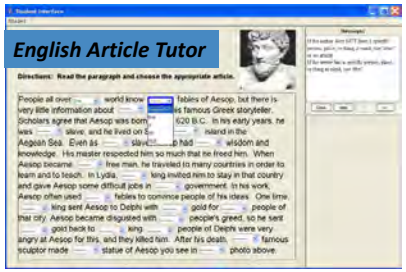


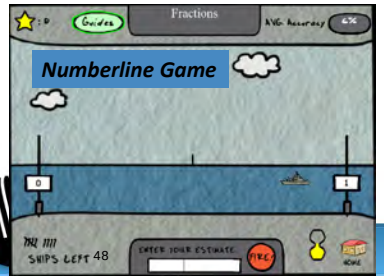
Koedinger, Corbett & Perfetti. (2012). The Knowledge-Learning-Instruction (KLI) framework: Bridging the science-practice chasm to enhance robust student learning. *Cognitive Science.*

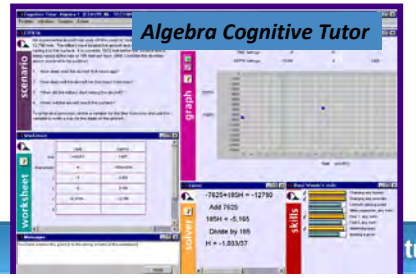
Overview

- ***Course big picture***
- Syllabus & Course Project
- Introductions
- Ch1: E-learning Promises & Pitfalls
- To do items

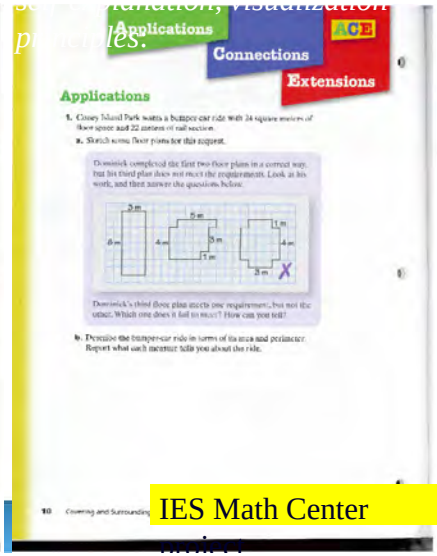
Data from a variety of educational technologies & domains







Modifying widely used textbooks



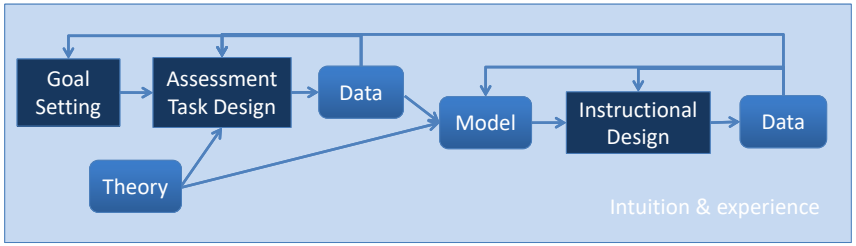
IES Math Center

MODEL Discovery

Why are tutors effective?

- Step-by-step feedback is timely and detailed
- Next-step hints reduce floundering
- Individualized problem selection can target areas of need (while avoiding over-practice, which would be a waste of time)
- Compared to the usual practice of assigning end-of-chapter problem sets as homework:
  - feedback is not as timely, not as detailed, resulting in floundering,
  - everyone gets the same problem set, resulting in over-practice for some and under-practice for others

Instructional Design Process: The BIG PICTURE



- *Goals* guide *assessment* tasks guide *instruction*
- *Theory, data, & model building* support decisions
  - *Intuition & experience* still relevant (but are nearly imperceptible)

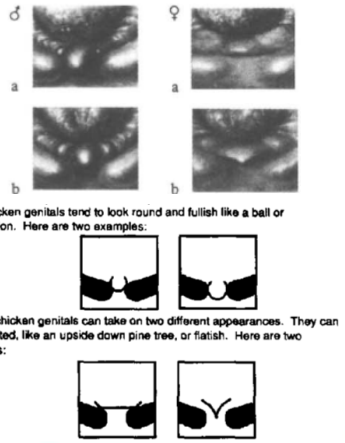
Overview

- Course big picture
- ***Syllabus & Course Project***
  - Find syllabus link on Blackboard
  - Course project is attached
- Introductions
- Ch1: E-learning Promises & Pitfalls
- To do items

Overview

- Course big picture
- Syllabus & Course Project
- ***Introductions***
- Ch1: E-learning Promises & Pitfalls
- To do items

Unpacking & repacking expertise: Chick sexing



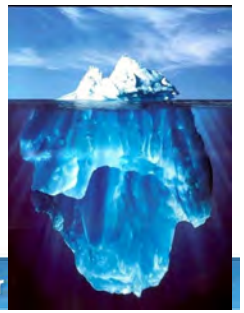
Male chicken genitals tend to look round and fullish like a ball or watermelon. Here are two examples:

Female chicken genitals can take on two different appearances. They can look pointed, like an upside down pine tree, or flatish. Here are two examples:

ederman & Shiffrar (1987). Sexing Day-Old Chicks: A Case Study and Expert Systems nalysis of a Difficult Perceptual-Learning Task. JEP: Learning, Memory, & Cognition.

You Don't Know What You Know

- You've had lots of experience with the English language
- You might say you know English
- But, do you know what you know?



Cognitive Task Analysis Methods

- Techniques to specify *cognitive structures & processes* associated with task performance
  - Think alouds of experts & novices performing tasks — Newell & Simon (1972)
  - Computer simulations of human reasoning — Newell & Simon (1972)
  - Structured interviews of experts — Clark et al
  - Difficulty Factors Assessments — Koedinger et al
  - Learning curve analysis

Introductions

- First and last name
  - If either is tricky to pronounce give a clue, such as "Koedinger" rhymes with "play ringer"
- Degree program here at CMU
- For a e-learning design project
  - Do you have a content area that you are particularly interested in?
  - Do you have a technology you are particularly interested in?
  - Any other ideas for a possible project?

Overview

- Course big picture
- Syllabus & Course Project
- Introductions
- ***Ch1: E-learning Promises & Pitfalls***
  - Questions on reading?
- To do items

Overview

- Course big picture
- Syllabus & Course Project
- Introductions
- Ch1: E-learning Promises
- ***To do items***
  - Examples assignment
  - Get textbook!
  - For Thursday
    - Readings, quiz, start examples assignment

Extras if time …

- Some examples of cutting-edge ed tech from CMU!!

CMU Learning Science Highlights

- Real-world impact of Cognitive Tutors
  - 500,000 students per year!
  - many full year evaluations
- LearnLab:
  Pittsburgh Science of Learning Center
  - $50 million national center
    - Ten years of funding: 2004-14
  - Field-based basic research
    - Improve learning science via technology use in schools

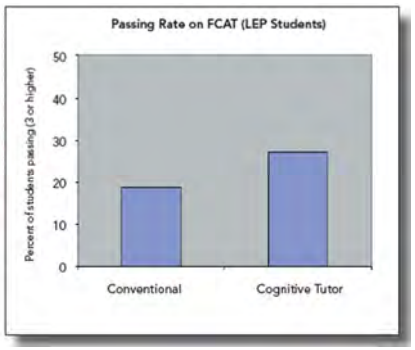
Cognitive Tutor Math Courses Making a Difference

The New York Times **Technology**

Software Tutors Offer Help and Customized Hints

Chris Maynard for The New York Times

MATH COACH - Rochelle Brown, left, and Iesha Antonetti, students at Middle School 103 in the Bronx, use Cognitive Tutor software to reinforce math skills. The software is designed to give students individualized instruction when personal attention is scarce.



- Widespread use: 500,000 students
- Data gold mine!

Major strands of learning science research

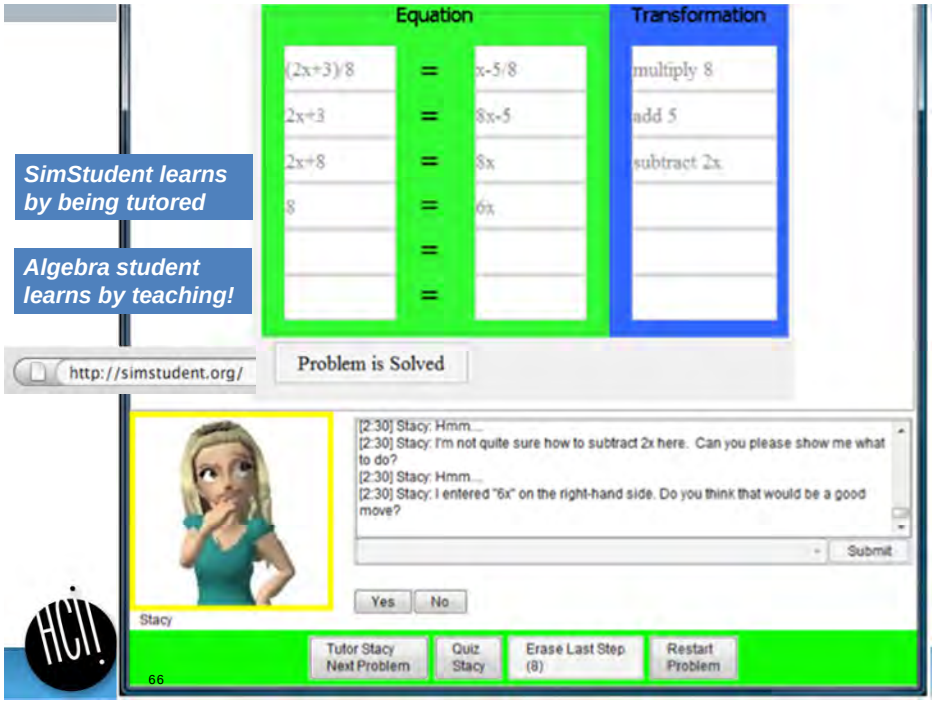
1. Model *learning* processes
2. Model & tutor *metacognition*
3. Use *natural language dialogue* tech
4. Tools for intelligent *tutor authoring*
5. Educational data mining
6. Use of *entertainment technology* to foster learning in & out of school

SimStudent
A Computational Model of Learning

http://simstudent.org/

Goals

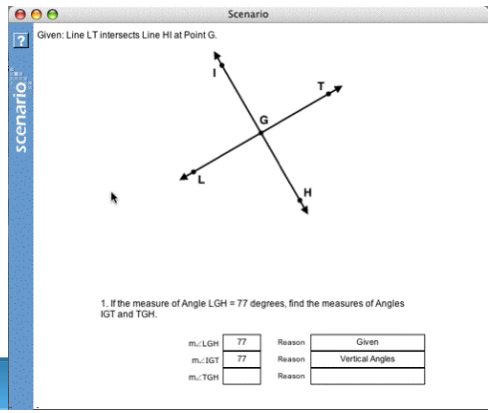
- Authoring: Program intelligent tutors by demonstration & feedback
- Science: Model how students learn
- Education: Help students learn by teaching (& caring) for an agent



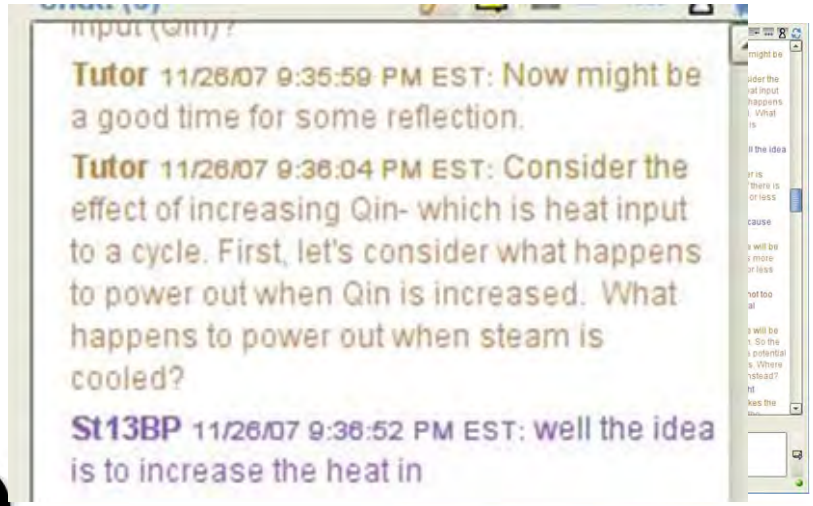
Assessing & Tutoring Meta-Cognition

Can educational tech help students "learn to learn"?

- student self-explanation
- error self-correction
- collaboration skills
- *help-seeking skills*

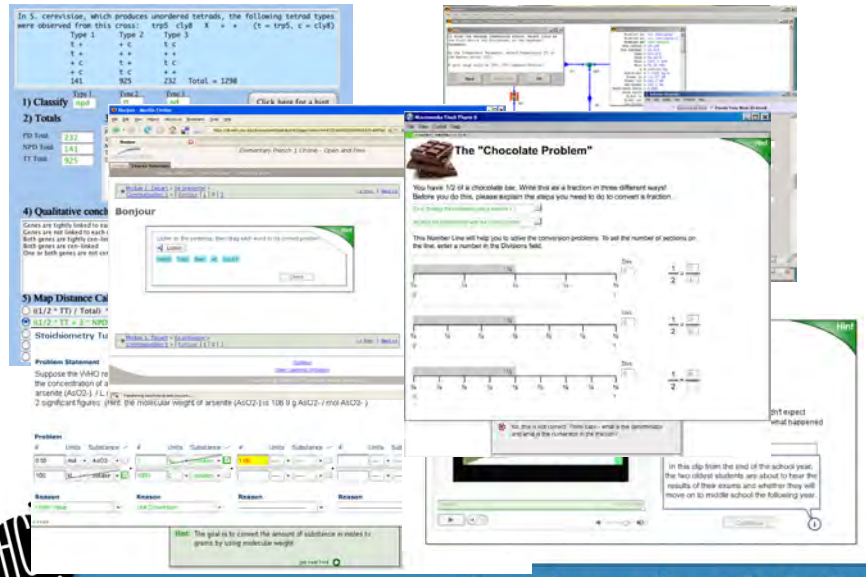


Example 3: Conversational Agents for Collaborative Learning



CTAT CognitiveTutorAuthoringTools

Software that enables you to author intelligent tutor behavior

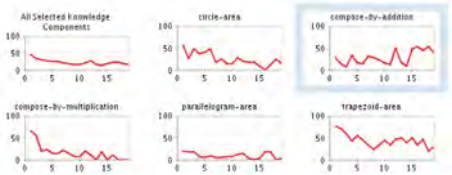


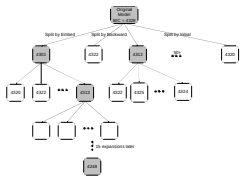
Machine learning detectors of motivation, reflection, affect

- Example: When are students "gaming the system"? (Baker, et al)
  - Classroom observers tag off-task behavior events
  - Apply machine learning -> automated detectors
  - Use detector to assess & give feedback on student work habits
- Also detectors of
  - Off-task vs. on-task long pauses
  - Deep vs. shallow reflection
  - Boredom, confusion, flow

Automated discovery of better cognitive models

- "Mixed initiative" human & machine learning
  - Visualizations to aid human discovery
  - AI search for statistically better models





- Better models discovered in Geometry, Statistics, English, Physics

Dataset name	Domain	Existing best BIC	# of KCs	LFA Discovered BIC	# of KCs	Improved BIC
Geometry96-97	Geometry Area	5606	12	5548	10	1%
Hampton0506	Geometry Area	15047	18	12476	15	17%
Cog discovery	Geometry Area	31183	49	31109	29	0.2%
Statistics - Fall 2009	Statistics	3611	14	3454	8	4%
IWT S-E Study 2	English articles	7162	19	7068	11	1%
Physics 2009 Spring	Physics	27051	239	24917	14	8%

Learning from Mixed-Reality Games

Playtesting at the Children's Museum

https://www.youtube.com/watch?v=9bvPOAiZK5g

https://www.youtube.com/watch?t=16&v=4M31Zh7t9eA