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

Ken Koedinger
Sharon Carver
Jessica Hammer
Erik Harpstead
Lauren Herckis
Ken Koedinger
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

Learning Science & Technology Ecosystem at Carnegie Mellon University

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

Learning & Training Continues to Boom!!

Edtech Market Projected to triple

Spending by area
The Education 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 Capital: $8.2 Billion*

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

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
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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)
- ...
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
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**
- Personalized Online Learning
- Design of Educational Games
- Applied Machine Learning
- Computational Models of Discourse Analysis
- Design & Engineering of Intelligent Information Systems
- Role of Technology in Learning in the 21st Century
- The Big Data Pipeline
- Mobile Service Innovation

**Learning Science**
- Cognitive Development
- Human Expertise
- Applications of Cognitive Science
- Research Methods for the Learning Sciences
- Role of Technology in Learning in the 21st Century
- Scientific Research in Education
- Learning Analytics and Educational Data Science

**Design**
- Human Factors
- Stats: Experimental Design for Behavioral and Social Sciences
- Design of Educational Games
- Service Design Social Perspectives in HCI
- Computer Science Perspectives in HCI
- Research Methods in Human Centered Design
- Learning Media Design
- 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

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Application Guidelines

• Apply Online
• 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 undergrad, 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

Learning events

Instructional events

Assessment events

Exam, belief survey

Knowledge Components

Instructional events
- Explanation, practice, text, rule, example, teacher-student discussion

Learning events
- Question, feedback, step in ITS

Knowledge components

Exam, belief survey

Overview

- Course big picture
- Syllabus & Course Project
- Introductions
- Ch1: E-learning Promises & Pitfalls
- To do items
Modifying widely used textbooks

Connected Math text before: After applying
worked example, self-explanation, visualization
principles:

IES Math Center

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

Unpacking & repacking expertise: Chick sexing

**Unpacking & repacking expertise: Chick sexing**


• Interviews led to design of "pictures in which critical features of various types were indicated"
• After just minutes of instruction, novices brought to 84% accuracy!

You Don’t Know What You Know

**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
  - Computer simulations of human reasoning
  - Structured interviews of experts
  - Difficulty Factors Assessments
  - Learning curve analysis

Newell & Simon (1972)
Clark et al
Koedinger et al

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

To do items

- Examples assignment
- Get textbook!
  - For Thursday
    - Readings, quiz, start examples assignment
Extras if time ...

- Some examples of cutting-edge 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

- 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
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
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

Learning from Mixed-Reality Games

https://www.youtube.com/watch?v=9bvPOAIzKS
https://www.youtube.com/watch?v=4M31Zh7t9eA