Are You Students Learning? Prove It!

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Why a learner-centered approach?

- Learning results from what the student does and thinks and only from what the student does and thinks. The teacher can advance learning only by influencing what the student does to learn.

  Herbert Simon, Nobel Laureate 2001

- It’s not teaching that causes learning. Attempts by the learner to perform cause learning, dependent upon the quality of feedback and opportunities to use it.

  Grant Wiggins
  President, Center of Learning Assessment

Cognitive Task Analysis example: What is hard 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

Data contradicts common beliefs of researchers and teachers


Goals of ChemVLab+ Activities

- Provide an open-ended simulation environment that supports inquiry
- Address limitations of pencil and paper activities (not to replace real labs!)
- Help students make connections between procedural knowledge with conceptual understanding and chemical reasoning

ChemVLab+ Features

- Authentic problem-solving contexts
- Support connections between multiple representations of chemistry
- Embedded Assessment
  - Immediate Feedback via Intelligent Tutoring
  - Reports to Students and Teachers
Can we make learning something you can observe?
Another Example - Fractions

• Common Core Teaches Fractions: + - * /

\[
\frac{4}{5} + \frac{3}{5} =
\]

• But what about

\[
\frac{4}{5} + \frac{3}{7} =
\]

What's the hidden skill?

http://www.corestandards.org/Math/Content/5/NF/
The Simon Initiative Vision

- A data-driven virtuous cycle of learning research and innovative educational practice causes demonstrably better learning outcomes for students from any background or place.

Simon Initiative Learning Engineering Methodology

- Learning Objectives
- Sub-Objectives
- Instructional Material
- Activities
- Problem Steps
- Knowledge Components

Carnegie Mellon University
We can’t just **apply** learning science, we must **do** learning science for continuous improvement.

\[ >3^{15}\times 2 = 205 \text{ trillion options!} \]

Science & Technology underlying Cognitive Tutors

- **Cognitive Model**: A system that can solve problems in the various ways students can.

If goal is solve $a(bx+c) = d$
Then rewrite as $abx + ac = d$

If goal is solve $a(bx+c) = d$
Then rewrite as $abx + c = d$

If goal is solve $a(bx+c) = d$
Then rewrite as $bx + c = d/a$

$6x - 15 = 9$
$2x - 5 = 3$
$6x - 5 = 9$

- **Model Tracing**: Follows student through their individual approach to a problem -> context-sensitive instruction.

- **Knowledge Tracing**: Assesses student's knowledge growth -> individualized activity selection and pacing.

Learning Curve Analysis

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Other Learning Curves

LearnLab DataShop

DataShop: Pittsburgh Science of Learning Center
What’s needed to make progress?

- Traditional Approaches
- RCT
- In Vitro Studies
- Extended Studies
- Isolation of Variables

To make progress requires:

- Constant, ongoing, informed changes to learning materials
- Careful consideration of use, practice and context
- Transparency

Learner Center Approach in Practice

- Scientifically-based online learning environments based on technology and the science of learning with teaching.
- OLI is designed to simultaneously improve learning and facilitate learning research.
The Open Learning Initiative

• Since 2002...
• Exemplar of scientifically-based online courses (learning environments) that enact instruction and support instructors.
• Support better learning and instruction with high-quality, scientifically-based, classroom-tested online courses and materials.
• Share our courses and materials openly and freely so that anyone can learn.
• Develop a community of use, research, and development.

27+ Ready to Use Courses

• American English Speech
• Arabic For Global Exchange
• Anatomy & Physiology
• Argument Diagramming
• Biochemistry
• Elementary French I
• Elementary French II
• Engineering Statics
• Elementary Spanish I
• Elementary Chinese I
• Evidence-Based Practice In Management And Consulting
• Health Information Technology Foundations
• Introduction To Biology
• Introduction To Chemistry
• Introduction To Psychology
• Introduction To Visual Design
• Logic & Proofs
• Media Programming
• Modern Biology
• NSC STEM Pathways
• Principles Of Computing With Python
• Probability & Statistics
• Public Policy Analysis For Engineers
• Responsible Computing
• Statistical Reasoning
• STEM Foundations
• STEM Readiness

Learning design as hypothesis

• Learning Design as Hypothesis:
  – What does this mean?
- Learning Design as Hypothesis:
  - What does this mean?
  - Is this a traditional approach to instruction?

- Learning Design as Hypothesis:
  - What does this mean?
  - Is this a traditional approach to instruction?
  - What is required?

- Is my hypothesis complete enough for testing?

- Is my hypothesis complete enough for testing?
  - Is my design complete enough for testing?
What do you know about your instruction?

What is performance of specific activities and questions?
- Is it being used?
- How are students doing on their first try?
- Do they ever get it right?
- How much time do they need?

• How well aligned is practice and high-stakes activities?
• Do students that succeed in practice succeed on quizzes/exams?

• Structure:
  • How much practice available for a given skill?
  • How much assessment for a given skill?
Given this learning design as hypothesis framing:

– What does success look like?
– What kind of improvements can we make to a course?

Tools in progress

Designing Courses

Cognitive Tutors: Adaptive Support for Learning by Doing
Masters of Educational Technology and Applied Learning Science

- Interdisciplinary Professional Masters
- Create effective instruction and educational technologies
- Seven-month capstone project
- Learning Engineers ready to apply evidence based research
- 100% Placement
- 12 months

metals.hcii.cmu.edu
Understand Needs

Understand Research

Create Effective Designs

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

2018 Simon Initiative
LearnLab Summer School

- Monday, July 23 – Friday, July 27
- Intense one week – four tracks
  - Building online courses with OLI
  - Educational Data Mining, Statistics, and Machine Learning
  - Developing Intelligent Tutors
  - Building collaborative learning environments

Questions?

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