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Executive Director, Simon Initiative
Director, Open Learning Initiative

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“Improvement in post-secondary education will require converting teaching from a solo sport to a community-based research activity.”

CMU as a learning science and edtech hub
Making learning something you can observe
Learning Engineering

Apply, extend and accelerate **Learning Engineering**:

- To improve learning for CMU students
- To improve learning outcomes for all
- To advance our understanding of human learning
Learning Engineering

Works to demonstrably improve learning outcomes

Primary Education

Global Learning XPRIZE Finalist
- Based on learning science
- Uses advanced technologies
- Data-driven design
- Swahili version field-tested in 30 villages
Secondary Education: Cognitive Tutor Algebra


Secondary Education: Cognitive Tutor Algebra

- 10M+ students supported
- Technology 2 days/week
- Collaborative learning 3 days/week

Pane, et al. (2013). Effectiveness of Cognitive Algebra I at Scale. RAND Corp.
Higher Education: OLI Statistics

6x the learning gains in ½ the time

Replicated results at CMU
- Larger class
- Different instructor

OLI students also show
- Greater retention
- Better transfer of skill

Independent trial at 6 other public institutions: also replicates


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New (and Old) Challenges in Education

• Changing nature of work
• Uncertain funding and budget models
• Accelerating changes in technology and skills needs
• Evolving career pathways
• Ever-more diverse learner population
• Demographic trends
• Variability in effective practice...
• ...
These challenges are too big for any single institution to solve alone

• How can we expand the application of the learning engineering approach?
• How can we drive ongoing improvements to learning engineering?
• How can we ensure the insights and successes from learning engineering are broadly shared (and critically evaluated)?
• Make Learning Engineering Usable by Everyone
• Make Improving Education a community-based Research Activity

• Infrastructure
• Incentives
• New research approaches
• Better understand barriers and facilitators
• Make Learning Engineering Usable by Everyone
• Make Improving Education a community-based Research Activity

Ecosystem: Community + Tools

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OpenSimon:
Building a Community

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OpenSimon Community

- Support across multiple roles, types of institutions, types of learners
- Problem-oriented
  - What are common challenges?
  - How can OpenSimon tools and approaches address?
- Collaborations: Research, Infrastructure, Funding, Findings
- Leveraging work with Empirical Educator Project (EEP)

OpenSimon Toolkit:

Learning Engineering for Everyone

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Lifecycle of Educational Projects

Discover → Design → Develop → Deliver → Discover

to support applying learning engineering to the life cycle of educational projects

OpenSimon Toolkit

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Discover — Design — Deliver — Develop

Discover — Design — Deliver — Develop

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From $100M of tools...
...to an open ecosystem
...to an open ecosystem

Techniques and Tools — Openly Available

**DESIGN**
- Cognitive Task Analysis
- skill mapping
- Echo

**DEVELOP**
- Tag activities to outcomes
- multiple practice opportunities
- CTAT
- Echo

**DELIVER**
- Authentic activities (CTAT, DANCE, etc.)
- collect data
- OLI

**DISCOVER**
- RISE
- Learning Curve Analysis
- Causal Inference
- LearnSphere
- TETRAD
OpenSimon Toolkit:

Spotlight: OLI

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OpenSimon Tools

Echo: OLI Course Authoring and Improvement Platform

OLI Delivery Platform
Scientifically-based, open courseware based on
the integration of technology and the science
of learning with teaching. OLI is designed to
simultaneously improve learning and facilitate
learning research.

• Open, Designed Materials
• Instrumented Delivery
• Integration with OpenSimon
• Authoring
• Skills mapping
• Improvement Analytics
Learning Design as Hypothesis

Technique: Skills Mapping

Technique: Design Audit

Is My Hypothesis Complete Enough for Testing?
OLI Authoring: Design Audit

Use the criteria of currency, relevance, point of view and authority to evaluate sources in relation to particular research goals and objectives.

Legend

Skills should have at least 3 narrative questions.

- Evaluate a source on its currency.
- Evaluate a source on its point of view.
- Evaluate a source on its relevance.
- Evaluate a source on its authority.

Iterative Improvement:
Learning Curve Analysis

Datashop/Learnsphere Integration
Iterative Improvement: Learning Curve Analysis

Datashop/Learnsphere Integration

Iterative Improvement: Does activities support assessments?

Datashop/Learnsphere Integration
Iterative Improvement:
Does activities support assessments?

Datashop/Learnsphere Integration

Iterative Improvement:
Learning Activities

OLI Authoring Tools
Questions

Are there existing OLI courses that could help support your learners or address learning challenges?

Head to oli.cmu.edu to use courses now. Full code release planned for October

Would you like to revise existing materials or create new instrumented courseware?

The OLI authoring platform is ready to use at echo.oli.cmu.edu. The code is openly licensed and available on github.

OpenSimon Toolkit:

Spotlight:
DataShop/LearnSphere/Tetrad
LearnSphere + Tetrad Tools Produce Discoveries You Can Use

Psych MOOC+OLI Analysis
What student choices associate with most learning?
Discovery: What student choices associate with most learning?

Learning by doing > 6x better than learning by watching or reading!

Discovery: Does doer effect apply across courses?

Which learning resources are making the most difference in your courses?

Try this workflow on your data at LearnSphere.org!

Koedinger et al. (2015). Learning is Not a Spectator Sport: Doing is Better than Watching for Learning from a MOOC. Proceedings of Learning at Scale.

Delivery, Data for Discovery
Four OLI courses with 12,500 students

<table>
<thead>
<tr>
<th>Course</th>
<th>Students using online materials</th>
<th>Activities available</th>
<th>Activities done mean (st dev)</th>
<th>Readings available</th>
<th>Mean Readings done (st dev)</th>
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<tr>
<td>Information Systems</td>
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<td>94.4 (88.8)</td>
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<td>881</td>
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<td>687</td>
<td>621 (114.5)</td>
<td>545</td>
<td>510 (236.9)</td>
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</table>

Discovery
Consistent doer effect across courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Quiz Adj R^2</th>
<th>Doing std coef</th>
<th>Reading std coef</th>
<th>Effect ratio</th>
<th>Final Grade Adj R^2</th>
<th>Doing std coef</th>
<th>Reading std coef</th>
<th>Effect ratio</th>
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<td>0.124</td>
<td>5.2</td>
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<td>0.227</td>
<td>0.105</td>
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<td>-0.127</td>
<td>~</td>
<td>0.11</td>
<td>0.327</td>
<td>0.020</td>
<td>16.4</td>
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<tr>
<td>Psych</td>
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<td>0.781</td>
<td>0.092</td>
<td>8.5</td>
<td>0.45</td>
<td>0.654</td>
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<td>Psy MOOC</td>
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<td>0.08</td>
<td>0.259</td>
<td>0.054</td>
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</table>

Doing to reading effect ratio: 2.2x to >16x
- Median doer effect is 6x across 5 course instances & 2 measures
OpenSimon Toolkit:
Spotlight: RISE Framework

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Community In Practice

The Rise Framework

Learning analytics identify OER to target for improvement
(Bodily, Nyland, and Wiley, 2017)
Design
Develop
Deliver
LearnSphere

Discover

Resource
Inspection
Select
Enhancement

Learning analytics identify OER to target for improvement
(Bodily, Nyland, and Wiley, 2017)

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Outputs and Analysis

High

- High student prior knowledge
- Inherently easy learning outcome
- Highly effective content
- Poorly written assessment

Effective resources
- Effective assessment
- Strong outcome alignment

Low

- Low student motivation
- High life distraction
- Too much material
- Difficulty accessing resources

Poorly designed resources
- Poorly written assessments
- Poor outcome alignment
- Difficult learning outcome

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LearnSphere Lumen-Contributed Component

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<th>A</th>
<th>B</th>
<th>C</th>
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</tr>
<tr>
<td>25</td>
<td>u03_m01_c</td>
<td>0.9725</td>
</tr>
</tbody>
</table>

Inputs and workflow

Questions

Do you have a data set with differences in student learning resource use and student learning outcomes?

If so, you can use LearnSphere & Tetrad to discover what’s effective

Do you have analyses you’d like to see used and improved more broadly?

If so, you can contributes as workflow components to Tetrad for sharing

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“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.”
Institutional Lessons Learned

Start with the need

Provide multiple types of support

Build to test and iterate

Three Need-Driven Case Studies

1. Varying levels of preparation

2. Common “crunchpoints”

3. Cross-institutional core competencies
Lifecycle of Educational Projects: Focus on **Closing the Loop**

- Discover
- Design
- Need-Based and Data-Driven
- Deliver
- Develop

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Lifecycle of Educational Projects: Focus on **Institutional Context**

- Discover
- Design
- Need-Based and Data-Driven
- Deliver
- Develop

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Case 1: Leveling the Playing Field

**Need:** Some CS students struggle in required math theory course

**Approach:** Provide self-paced, interactive modules on key prerequisite skills before students matriculate

*For what conditions on sets A and B does \( A - B = B - A \) hold?*

---

Case 1: Starting the Cycle

**Design** instruction mapped to target skills

**Develop** modules in OLI

**Deliver** to all CS students Summer ’16

Support:

- Learning Engineer: coach (more practice problems!) and project manager
- Teaching Consultant: guidance on pre/post-test and framing

modules to students
Case 1: Discover

Logic:

Functions:

Case 1: Closing the Loop

Data-informed refinements implemented:

- Add practice & feedback on targeted skills
- Improve assessments

Learning Engineer supports ongoing iteration
Case 1: Another Loop

Data suggest need for more alignment to open-ended problems in math course

...Integrate CTAT tutors

Math faculty requested modules for their majors

Case 2: Addressing “Crunchpoints”

**Need:** Across English composition courses, students have difficulty with Prose Style but there is little/no room to add it

**Approach:** Create supplementary OLI modules
**Case 2: Starting the Cycle**

Although Hoover was in reality a warm, good-hearted individual, on the surface he often gave the appearance of being an emotionless, machinelike politician, interested only in statistics, reports, and fact-finding surveys.

1. Identify the nominalization that follows an empty verb.

   [Blank]

2. Change the nominalization into a verb.

   [Blank]

3. Rewrite the sentence by replacing the empty verb + nominalization with the new verb.

**Case 2: Discover... Design**

- Significant pre/post gains
- Learning curve analysis identified which skills need more work (and refined learner model)
- Still some common errors in open-ended responses
- ...Integrate LightSIDE to automate feedback on open-ended responses
Case 3: Developing Core Competencies

**Need:** Infuse collaboration instruction across the institution with little/no impact on instructors

**Approach:** OLI modules with virtual-team practice followed by face-to-face activities with teammates

Case 3: Closing the Loop

Randomized, controlled trial shows OLI modules lead to better:

- Knowledge on effective teamwork
- Peer ratings of teamwork
- Final team product
- Attitudes about teamwork

Pre/post gains significant, positive for CollabU students except for a specific topic
Case 3: Closing the Loop

Randomized, controlled trial shows OLI modules lead to better:
- Knowledge on effective teamwork
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Pre/post gains significant, positive for CollabU students except for a specific topic

Case 3: Take-Aways

- Approach works for behavioral skills like collaboration
- Demonstrable learning gains
- Broad applicability
  - First-year and capstone courses
  - Undergrad and grad students
  - STEM, Public Policy and Design teams
- CMU adoption: ~1500 students, 25 courses, 50 faculty
- Taken to scale in independent or hybrid mode
Institutional Benefits

• Promoting and supporting teaching innovation
• Demonstrating value added for students and measurable learning gains
• Leveraging data to close the loop
• Shifting institutional culture

Questions

• Which of these needs and strategies resonate?
• What are additional need cases at your institution?
• What support do you have or can you develop?
• What lessons have you learned?
• How can we partner in shifting the education paradigm?
Discussion

- Next Steps:
  - More Information at http://cmu.edu/simon/opensimon
  - Sign-up for updates
  - Find the full array of tools, techniques, content and code

- Future webinars and events

- This just scratches the surface; how can we get you more information to make the community and toolset actionable? What tools would be your priorities?

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