Engaging Engineering Students at Scale: Technological Innovation and Organizational Change

Milo Koretsky
Problem Solving: Procedural Approach

**Example**
- Given $T$
- Step 1
- Step 2
- Step 3
- Step 4
- Find $P$

**Homework**
- Given $T$
- Step 1
- Step 2
- Step 3
- Step 4
- Find $P$

**Exam**
- Given $P$
- Step 4
- Step 3
- Step 2
- Step 1
- Find $T$
Objective: To develop conceptual understanding by removing the “calculation procedure” from the question
A constant-volume tank contains CO$_2$ at 2 atm. Nitrogen is injected into the tank. What happens to the partial pressure of CO$_2$ if it all remains in the tank? Assume ideal gases and an isothermal system.

13 A. Decreases
32 B. Increases
6 C. Stays the same (chance is 17)
Learning Landscape

Knowledge Structures

Technology Development
The AIChE Concept Warehouse
Instructor assigns a conceptual question

Students answer individually

Students discuss in groups

Instructor reassigns the question

Instructor shows class response and discusses
Learning Landscape

Knowledge Structures → Disciplinary Practice

Technology Development

Industrially-Situated Labs
Virtual Process Development Tasks

Chemical Vapor Deposition Reactor

Bio Reactor
Students must develop a “recipe” to grow Si$_3$N$_4$ film with uniform thickness, by:

Choosing the 9 Virtual CVD Reactor parameters, and then

- Pressure: mTorr
- NH$_3$ Flow: sccm
- DCS Flow: sccm
- Reaction time: min
- Zone 1: °C
- Zone 2: °C
- Zone 3: °C
- Zone 4: °C
- Zone 5: °C
Students must develop a “recipe” to grow Si₃N₄ film with uniform thickness, by:

Choosing the locations on the wafer to measure

Each run and each measurement costs $
Instructional Design

Deliverables

- Design Memo
  - Initial parameters
  - Budget
  - Experimental strategy

Begin Experiments

- Update Memo
  - Progress to date

- Final Report
- Final Oral Presentation
- Final Recipe
- Laboratory Notebook

Student-Coach Interaction

- Faculty Present
  - Background info
  - Intro to software

- Design Meeting
  - Discuss strategy
  - Students get authorization for VL

- Update Meeting
  - Discuss progress & strategy

- Final Presentations
  - 10-15 min present
  - 10-15 min questions from students, coach, 2 other faculty

Task Intro
End of Wk 1
End of Wk 2
End of Wk 3
Conceptions of Learning

“Students need to understand the concepts so they have the foundation to do engineering”

or

“By doing engineering students can recognize the salient concepts they need to learn”
Co-construction and Co-production

• Co-construction: cognitive talk directed at making meaning, trying to build connections between ideas and understanding, and answering how and why questions related to the knowledge underlying the task.

• Co-production: cognitive talk orientated at the completion of the set work that was prescribed by the instructor (in School World) or develop the process recipe and meet engineering objectives of the project (in Engineering World).
Conceptions of Learning

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or

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Doing and Understanding in Authentic Engineering Projects

Production

Construction

Production

Construction

Productive Disciplinary Engagement
Learning Landscape

Knowledge Structures

Disciplinary Practice

Industrially-Situated Labs

Technology Development

Organizational Change

Revolutionizing Engineering Dpts

Chemical, Biological & Environmental Engineering
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