Cognition and learning at the crossroads of the biosciences, engineering, and medicine

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Yesterday---survey results

• What needs to be in the core curriculum?
  • Courses (circuits, statistics, physiology), concepts

• What does industry want and is it in the core curriculum?
  1. Skills for problem-solving and trouble shooting
  2. Interpersonal communication
  3. Industry exposure
  4. Design experience
Evidence-based educational design

• How do BME experts reason and problem solve?
  • What are their preferred and practiced strategies for handling open-ended complex problems?

• What are the learning challenges associated with mastering these strategies?

• What does the developmental trajectory from novice to expert look like?

• How can the learning environment support and enhance that trajectory?
Translational studies of cognition and learning

**AUTHENTIC SITE**
cognition and learning in the wild

**LAB/Industry**

**SYNTHETIC**
cognition and learning under constraint

**Classroom/lab**

**DESIGN PRINCIPLES**

*In vivo*

*In vitro*
Translational studies 2002-2012

**NSF-funded study sites** (2 years each)

LAB 1--Tissue engineering-vascular tissue replacements

LAB 2--Neuroengineering-learning in vitro

LAB 3- Integrated systems biology lab (modeling only)

Lab 4- Integrated systems biology lab- hybrid modeling and benchtop experiments

**Questions**

1. nature of reasoning and problem solving in authentic interdisciplinary environments

2. kinds of tools, discourses, activities, representations utilized in interdisciplinary work

3. learning-kinds, challenges, support for developing skills/expertise in research settings (*ecological features*)
Arterial blood flow model

LAB 1
LAB 2

In vivo

In vitro

Brain-in-a-dish
Microfluidic device

LAB 4
I need to understand the effect of shear stress on endothelial cells. How can I do that?
What characterizes BME reasoning and problem solving?

- BMEs advance knowledge by iteratively constructing, manipulating, evaluating, and adapting models.
- BMEs often use conceptual, physical, mathematical, or computational models in conjunction.
- Interlocking models are the hallmark of BME work.
Translation into classroom design principles

1. Learning is driven by the need to solve problems.
2. Interdisciplinary problems demand that BMEs generate and work with interlocking models.
3. Problems require simulative model-based reasoning as a significant cognitive strategy.
4. Learning is relational (people and artifacts) cognitive partnering.
5. Learning is mediated through building, testing, failing, analysis and rebuilding.
What we have so far

- Courses and content
- Skills industry wants
- Socio-cognitive strategies that characterize BME approaches to problem solving

What kind of learning environments can we design to bring these all together?
Problem-driven learning (PDL)
A lattice model of curricular design

PDL-problem-driven learning
PIL problem-infused learning
PSS problem-solving studio
PDIL problem driven instructional lab
TC traditional classroom
Problem solving studio (PSS) format

Careful design of how students, instructors, and instructional materials are arranged in order to promote (or discourage) particular kinds of interactions

Teams of 2 sharing a blotter pad

At a table with another team of 2

Skilled participant + team of 2

Skilled participant + table
PSS enables multiple parallel and rapidly switching participant structures.
Problem-Based learning (PBL)

BME 2250: Problems in BME

Teams of eight students

1 undergrad facilitator/team
1 Faculty mentor/section
124 students; 17 TAs; 7 faculty

Special PDL classrooms with authorable walls
Parkinson’s disease (PD) is a devastating disorder affecting 1% of humans over 60 years old. More precise information about motor fluctuations over 1 day could a) help time the dosing of levodopa better, b) help adjust the dose of levodopa precisely, and c) provide a control signal for adaptive brain-stimulation approaches. An ideal device would capture the speed of movement, degree of stiffness, kind of tremor, minimize artifact size, and identify times over the day characterized by motor dysfunction. This device would have the capacity to be placed over the most affected areas and upload data to a remote device that can be viewed by a doctor or serve as a control signal for deep-brain stimulation.
Problem-driven learning (PDL)
A lattice model of curricular design

Integration

Science/math

TC

PIL BMED 3600

PDIL

PDL 2250

PDL

PSS 3310

PSS BMED 2210

Engineering

Department courses

Institute courses

PDL-problem-driven learning
PIL problem-infused learning
PSS problem-solving studio
PDIL problem driven
instructional lab
TC traditional classroom
Takeaways for today

• Educational translational research
  • Create synthetic learning environments that better replicate authentic learning and work environments (*simulated internships*)

• Start with the desired cognitive strategies and develop learning environments where they have multiple opportunities to practice them

• Undertake *systematic* curricular design based on learning principles

• Create a faculty development strategy where everyone is mentored and supported in developing and enacting alternative models for learning

• Bring a learning scientist onto your team.
Questions?