Creating Cognitive Apprenticeships for Undergraduate Learning

Wendy C. Newstetter
Wallace H. Coulter Department of Biomedical Engineering
Georgia Institute of Technology
Questions

• What will students learn from solving this problem?
• What are the challenges in using this in a class?
Biometric device malfunction

Two newer techniques for detecting the presence of fever are 1) through the measurement of ear temperature, and 2) through the measurement of forehead or temple temperature. Devices designed for these measurements are considered fast and easy to use, features that are particularly attractive for use on children. However, there have been numerous reports of concerns over the accuracy, reproducibility and repeatability of temperature measurements made with these new thermometers.

Your group is challenged with identifying a factor, other than device malfunction, which contributes to poor performance characteristics in one of these new thermometers. Performance characteristics include accuracy, reproducibility or repeatability. You will then develop an experimental design to test your hypothesis. Your experimental study, to be conducted with a thermometer purchased by your group, must be designed to use the number of human subjects necessary to produce statistically significant results.

Each group will present their proposed experimental study design on March 7th. Your next step will be to have your experimental protocol approved by the Georgia Tech Institutional Review Board (IRB) before beginning your study. All group members must be IRB certified as a precursor to this approval. Once you have approval, you will conduct the study. On April 27th, each group will present the results of its study. Final reports are due on April 28th.
Cognitive apprenticeship basics

• **A model of problem solving to practice**
  – Model-based reasoning in engineering

• **A complex, real-world problem**
  – Ill-structured, ill-constrained, many possible solutions
  – Demands extensive research/inquiry to solve

• **A tutor**
  – Facilitator/scaffold of the group process, not a content expert

• **A learning space for problem solving**
  – Space for writing, drawing and making knowledge explicit
How do engineers solve problems?

“The trick for an engineer is that you are never going to model real-life problems exactly... The trick...what you need to learn is making the right assumptions and simplifying it so you can analyze it. And I’ve struggled with this because I am more of an experimentalist than a theoretical guy....And I did a lot of stuff, experiments on retroviruses as a graduate student then this guy came in who was a theoretical guy and he wanted to do stuff with retroviruses and he did a model and when I first looked at it......it was informative...it turned out to be very informative...we got a paper out of it but when he first did it I was “This is really stupid.” He’s making all these ridiculous assumptions, but then Um...I realized it wasn’t stupid because I guess if you do the analysis mathematically it is just sooo rich and you know what the assumptions are so you can sort of ...Okay well this is what it is.... It gives you a much more in-depth understanding of things so.
How do experts solve these prob

Diagram

Symbols

Assumptions
- $C_i = \text{conc. & flux at air-liquid (mucus) interface}$
- $C_c = \text{conc. & flux at cell surface} = 0$

$D = \text{diffusion coeff. } \propto \nu \times \frac{R_B T}{6 \pi \mu _R}$

- $\nu = \text{viscosity} = 10^{-3} \text{Pa.s (water)}$
- $R_o = \text{virus radius} \approx 60 \text{nm}$
- $T = \text{temp. (310K)}$
- $R_B = \text{boltzmann coeff.} = 1.38 \times 10^{-23} \text{J/K}$

$$D_v = D_{v0} \approx \frac{1.38 \times 10^{-23} J/K (310K)}{6 \pi \left(10^{-3} \frac{J}{s} \text{m}^2 \right)(6 \times 10^{-8} \text{m})} = 3.8 \times 10^{-12} \text{ m}^2/\text{s}$$

$$D_v = 3.8 \times 10^{-8} \text{ cm}^2/\text{s}$$
The TDS Sequence in Engineering Problem Solving

Problem prompt
Text (T)

Transformation 1
Diagram (D)

Transformation 2
Symbol (S)

Textual account
The problem statement in words and sentences delivered in written/oral form.

Diagrammatic account
A visual diagram or schematic of the essential problem elements as they relate to each other. “Body of interest”

Symbolic account
Mathematical equations
ANALYTICO-DEDUCTIVE MODEL OF REASONING

1. **Problem**
   - Scenario
   - Inquire
   - Break into parts
   - Axioms/laws
   - Constrain/define problem
   - Create & apply models
   - Develop analytic framework
   - Solve problem

2. **Identify/seek/apply resources**
Learning outcomes of PBL

• Inquiry skills
• Knowledge acquisition skills
• Problem solving skills
• Team skills
Problem Transformation Cycle

Problem

Inquiry
Knowledge building
Problem solving
Communication
Team skills

Solution

Problem solving
Knowledge building
Communication
Team skills

Feedback & Evaluation

Group Presentation

Problem solving
Knowledge building
Communication
Team skills

Group Document

4-5 weeks/problem
3 problems/semester
SYSTEMS: Problem solving across the BME curriculum

Year 1
- PBL I
- 3 assigned problems; cognitive skills focused

Year 2
- PBL II
- 4 assigned problems; design focus
- Sys Phys lab I & II
- 2 student identified problems; lab technique application focus

Year 3
- Instrumentation Lab
- 1 student identified problem; lab technique application focus

Year 4
- Senior design
- 1 client identified problem; 2 terms
PBL rooms
Assessment strategies

• Behavior observation rubrics
  – Post-problem reflection sessions
    • Self/peer/team evaluation
    • Facilitator meeting
• Research notebooks
• Presentations
• Technical reports
• Self & Peer end-of-term assessment document
• Lecture quizzes/ Final exam
Final Exam PBL I

**Problem statement:**

There is lingering concern that cell phones may make people more susceptible to brain cancer. Design a study/experiment to either validate or invalidate this concern.

**Directions for answering the question**

*Step one [Rationale for your study/experiment]:* Identify and describe three possible experimental strategies for tackling this problem. Pick one and clarify your rationale for the choice.

*Step two [Inquiry Goals]:* Given your choice of strategy, identify information/questions you would need to address to move forward.

*Step three [Study/Experimental Plan]:* Propose a provisional hypothesis and an execution strategy for conducting the experiment/study and analyzing the results.

Make sure you incorporate any relevant concepts from the course that would be useful in tackling this problem.