Applying Research from *How People Learn* to Engineering Classrooms

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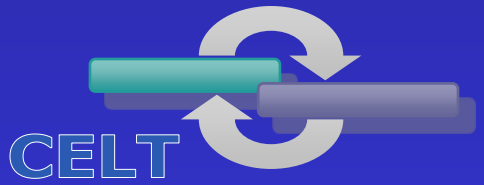
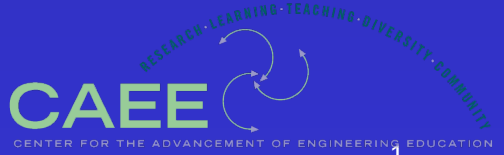
Cynthia J. Atman
Jim Borgford-Parnell
Center for Engineering Learning and Teaching
University of Washington

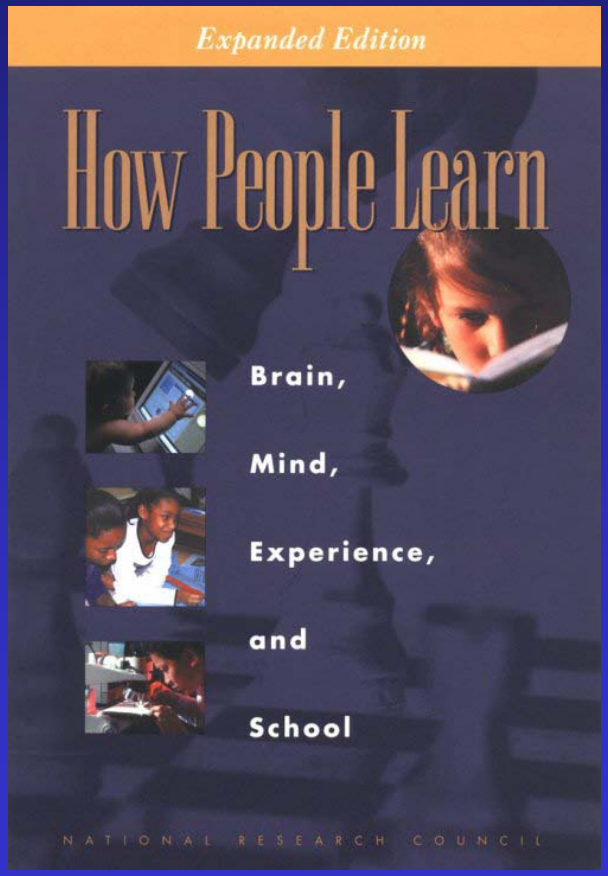


Co-Designed with
Jennifer Turns, University of Washington
Lorraine Fleming, Howard University



"*How People Learn*"

http://books.nap.edu/html/howpeople1/.



Source: National Resource Council (2000)

Why use "*How People Learn*" to inform teaching?

Important to understand how our students think and what they bring to the classroom (experiences, skills, prior knowledge, etc.)

How People Learn gives a valuable framework

Who are our students?

Emerging findings from the Academic Pathways Study (APS)

- Part of the NSF-funded Center for Advancement of Engineering Education (CAEE)
- Large scale, multi-method, longitudinal study of undergraduate engineering students
- Three cohorts of students from four very different undergraduate engineering programs and a group of early career engineers

Sheppard (lead), Atman, Fleming, Miller, Smith, Stevens, Streveler

APS Research Questions

Skills

- How do students' engineering skills and knowledge develop and/or **change over time**?

Identity

- How do these students come to **identify themselves as engineers**?

Education

- How do pre/engineering students **navigate their educations**?

Emerging Findings Across the Study:
From the student perspective

Large variation in student pathways . . . .

- Reasons for choice of major
  - Financial security
  - Contribution to society
  - Influence of family or mentors
- Curriculum and skill development issues
  - Heavy workloads, competition, stress
  - First two years give little “vision” of engineering (design and teamwork come late)
  - Understanding context vs. detail (a “systems” view)
- Perspectives on diversity
  - What it means to students’ views of becoming an engineer

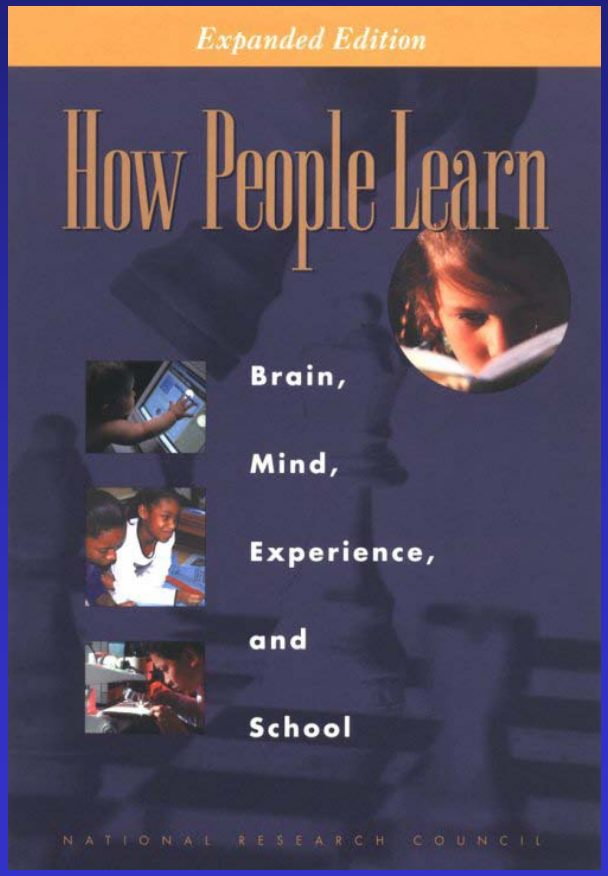
Emerging Findings Across the Study:
From the student perspective (cont.)

Large variation in student pathways . . . .

- Commitment to field of engineering
  - Affected by personal situation, learning experiences, institutional procedures
  - Decision to be an engineer re-examined often
- Reasons for leaving
  - Lack of confidence in math/science skills
  - Fear of losing scholarships
  - Perception that engineering is too narrow (often little understanding of the contributions of engineering to social good)
  - Factors affect men and women differently

"*How People Learn*"

http://books.nap.edu/html/howpeople1/.



Source: National Resource Council (2000)

Workshop Goals:

1. Explore research results from *How People Learn*

2. Think about ways these results might be applied in the context of your own classroom

Main Workshop Activity:
Think / Pair / Share

Think: Individually think about an assigned topic

Pair: Discuss your thoughts with a colleague

Share: Group discussion

Describe a topic you teach

Think: Think of a brief description of a topic you teach that you would like to focus on today (2 min)

Pair: Discuss with a colleague (4 mins)

"*How People Learn*"

Three main findings:

- Students have preconceptions
- Knowledge organization matters
- Students benefit from a "metacognitive" approach to instruction

Source: National Resource Council, How People Learn: Brain, Mind, Experience, and School, (2000)

1. Preconceptions

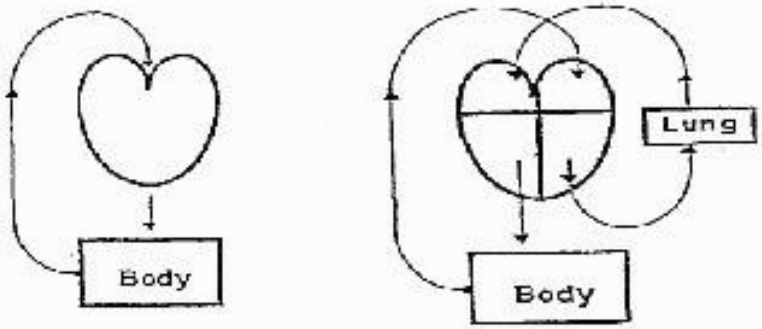
"Students come to the classroom with preconceptions about how the world works."

If their initial understanding is not engaged, they

- ✓ may fail to grasp the new concepts and information that are taught, or
- ✓ they may learn them for purposes of a test,
- ✓ revert to their preconceptions outside the classrooms."

Source: National Resource Council, How People Learn: Brain, Mind, Experience, and School. (2000). Chapter 1, p. 14-15.

Student Preconceptions

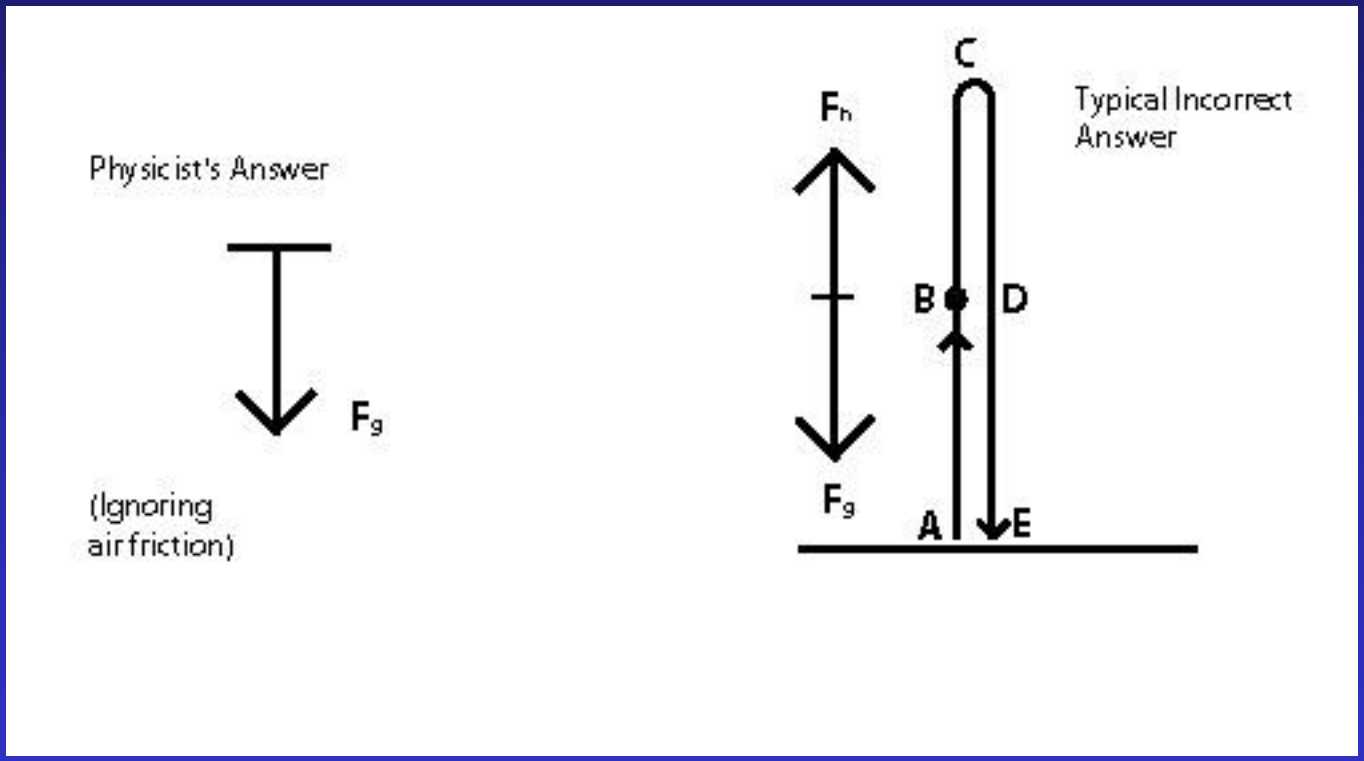


Assumptions	Single Loop	Double Loop
Source of oxygen	Heart	Lungs
Purpose of lungs	Destination of oxygen	Site of O_2 - CO_2 exchange
Number of Lungs	One	Two

Figure 1. Differences in the assumptions between a flawed single loop mental model and the correct double loop model.

Source: Chi, M.T.H., & Roscoe, R.D. In Limon, M. & Mason, L. (Eds.), (2002).

Student Preconceptions



Source: Clement, J. (1982).

Student preconceptions: Applying to your teaching

Think: In what ways could your teaching take into account student preconceptions? (2 min)

Pair: Discuss with a colleague (4 mins)

Share: Discuss as a group (4 mins)

Student preconceptions: Applying to your teaching
Ideas from workshop participants

Ideas....

2. Organization of Knowledge

"To develop competence in an area of inquiry, students must:

a) have a deep foundation of factual knowledge,

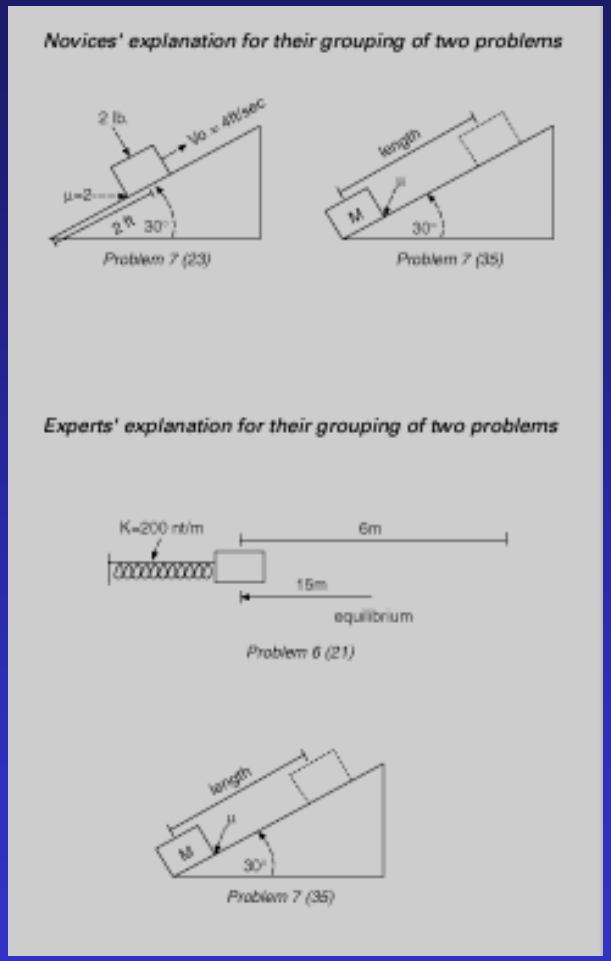
b) understand facts and ideas in the context of a conceptual framework, and

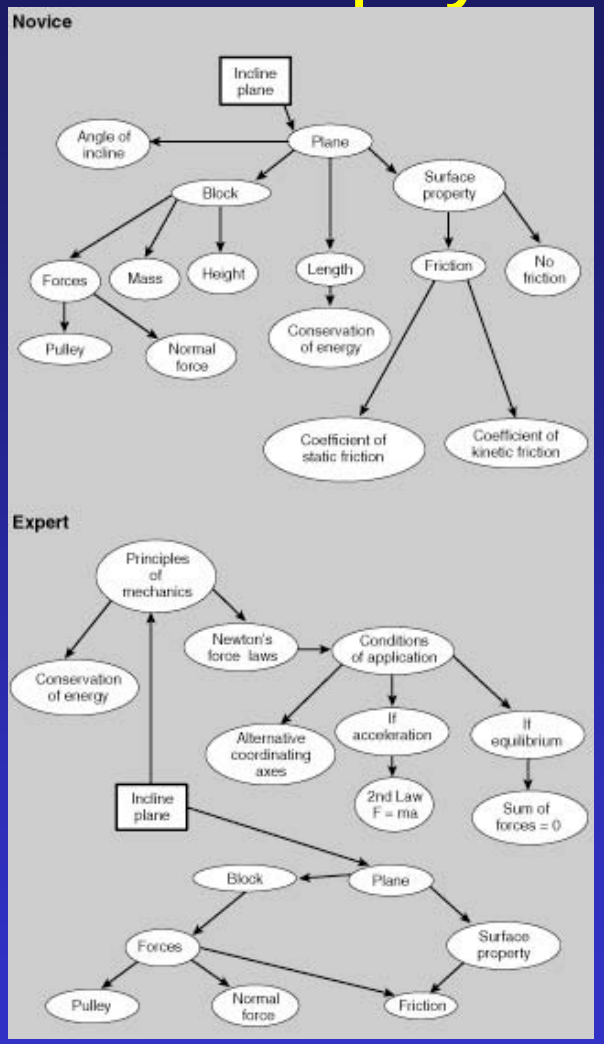
c) organize knowledge in ways that facilitate retrieval and application"

-> Draws on research on expert/novice differences

Source: National Resource Council, How People Learn: Brain, Mind, Experience, and School. (2000). Chapter 1, p. 16.

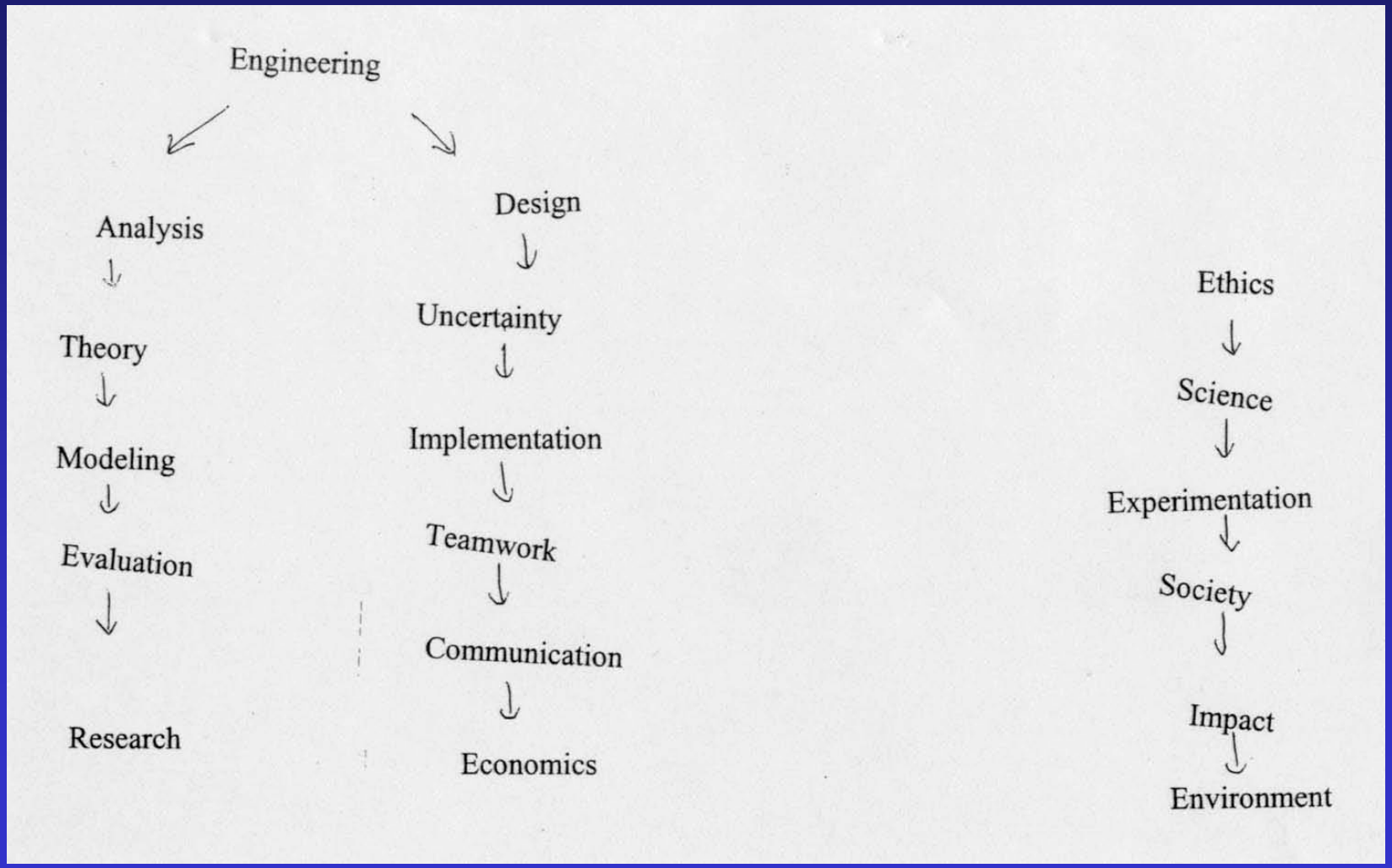
Expert/Novice differences in physics



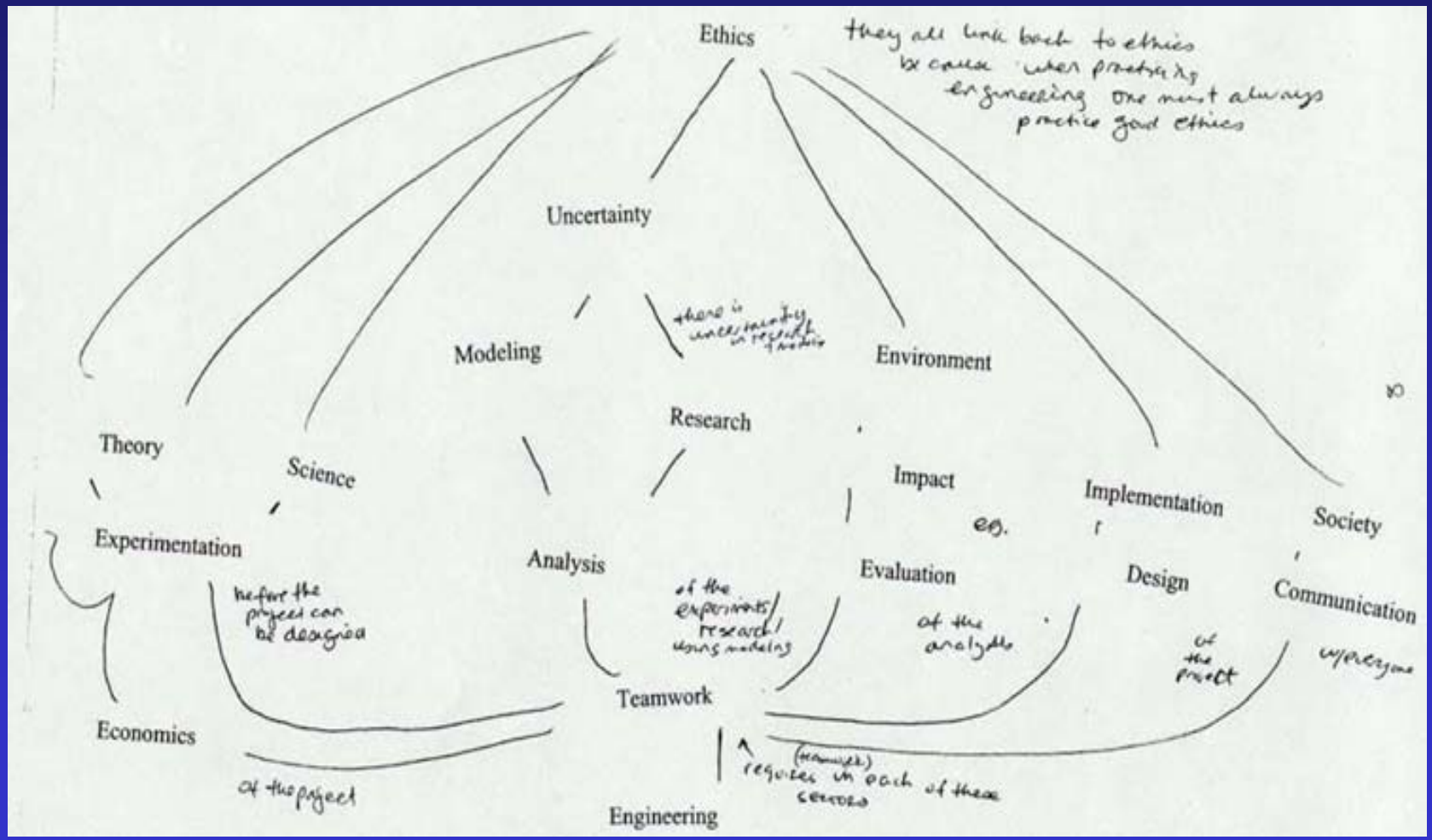


SCANNED from: National Resource Council, How People Learn: Brain, Mind, Experience, and School (2000). **Source**: Chi, M.T.H., P.J. Feltovich, and R. Glaser (1981).

Engineering Student Knowledge Networks

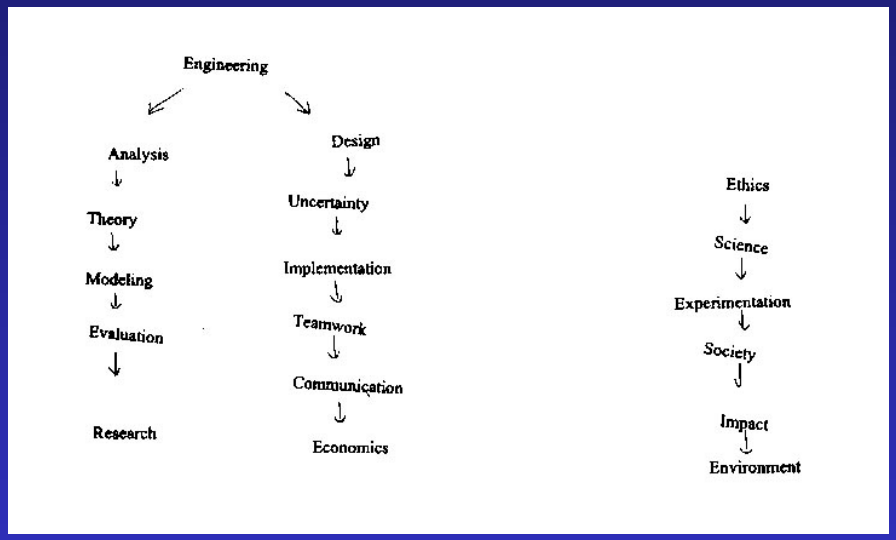


Engineering Student Knowledge Networks

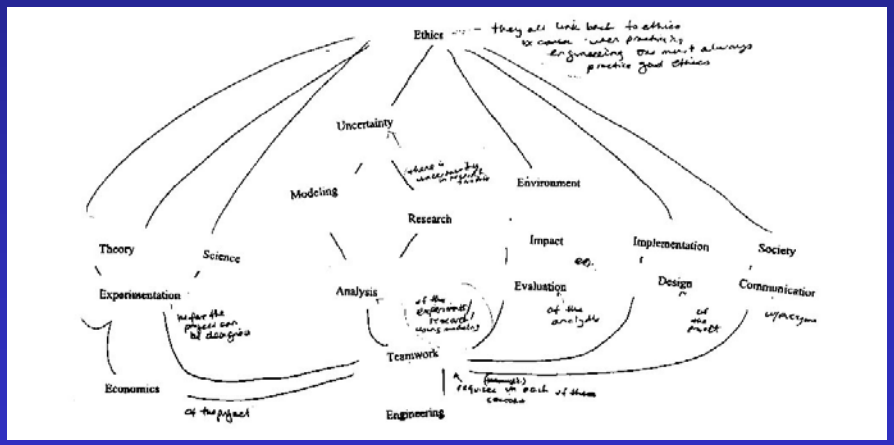


Engineering Student Knowledge Networks

Student One:



Student Two:



Source: Turns, Jennifer, Cynthia J. Atman, and Robin Adams (2000). "Concept Maps for Engineering Education: A Cognitively Motivated Tool Supporting Varied Assessment Functions," IEEE Transactions on Education Special Issue on Assessment 43 (2), pp. 164-173, May 2000

Knowledge Organization: Applied to your teaching

Think: In what ways could your teaching take into account knowledge organization? (2 min)

Pair: Discuss with a colleague (4 mins)

Share: Discuss as a group (4 mins)

Knowledge Organization: Applying to your teaching
Ideas from workshop participants

Ideas...

3. Metacognition

"A 'metacognitive' approach to instruction can help students take control of their own learning by defining learning goals and monitoring their progress in achieving them"

Source: National Resource Council, How People Learn: Brain, Mind, Experience, and School. (2000). Chapter 1, p. 18.

Metacognition

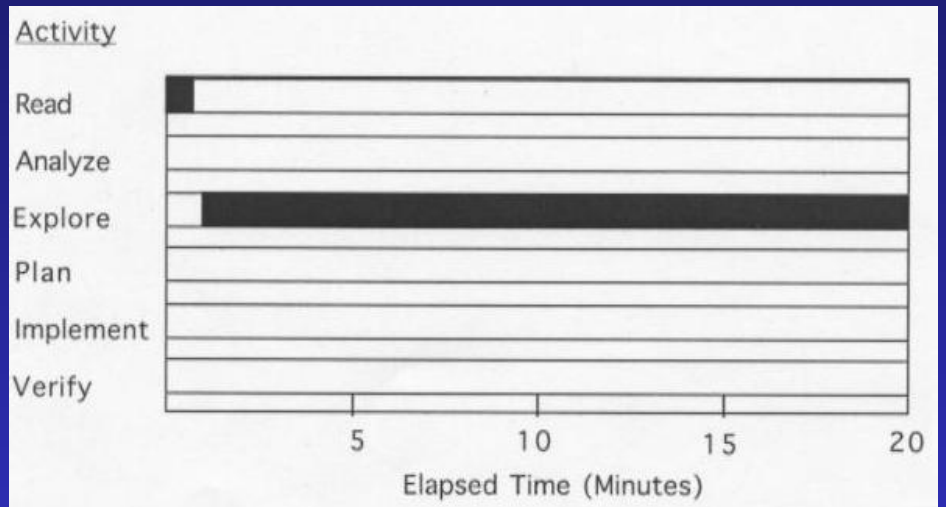


Fig. 3. Time-line graph of a typical student attempt to solve a non-standard problem.

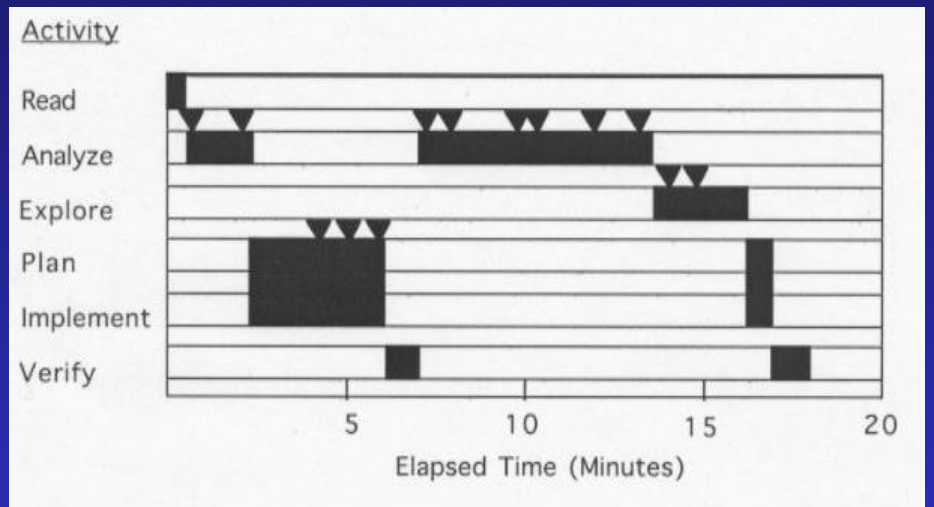
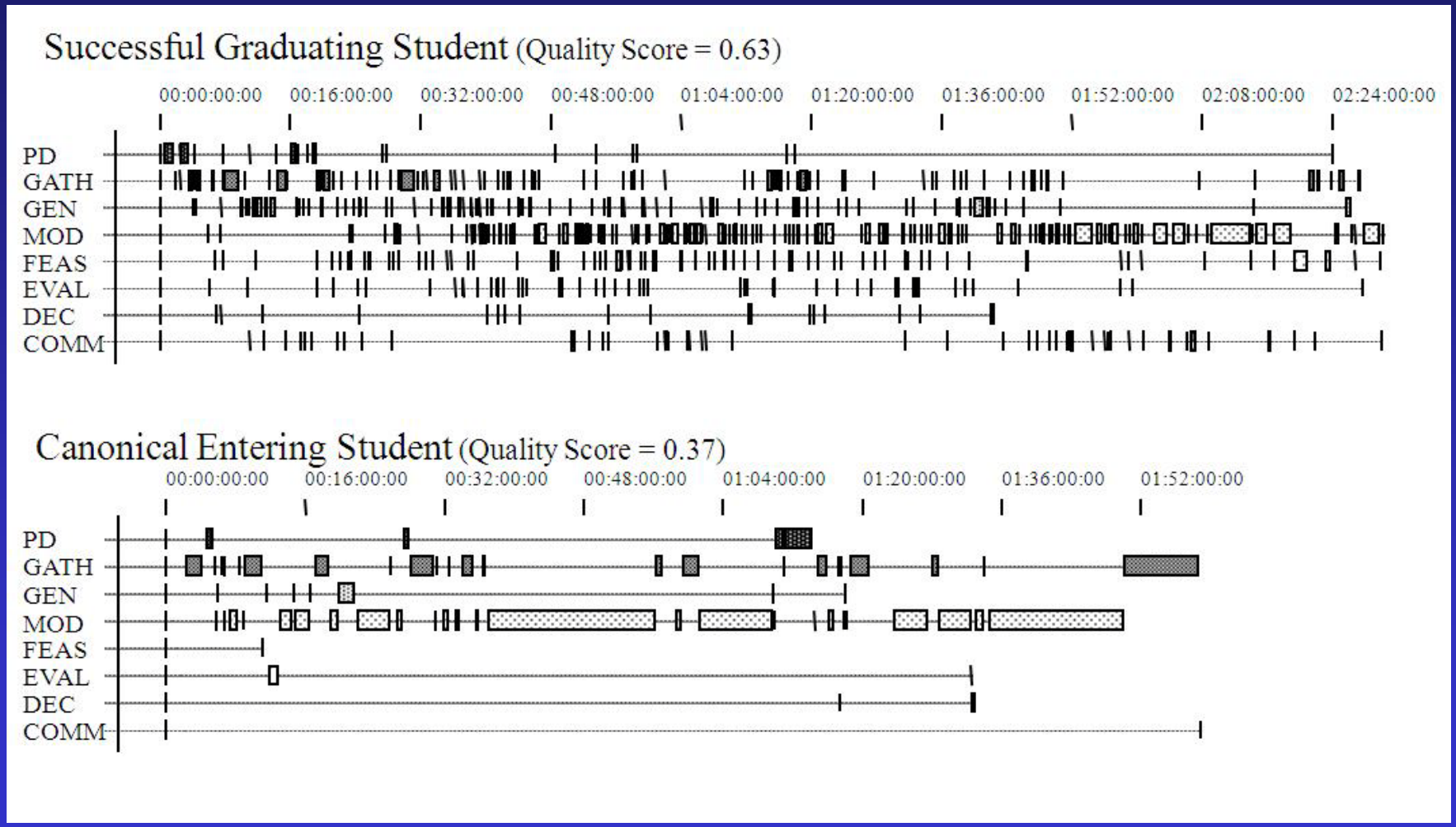


Fig. 4. Time-line graph of a mathematician working a difficult problem

Source: Schoenfeld, A.H. (1992). Learning to Think Mathematically: Problem-Solving, Metacognition, and Sense-Making in Mathematics.

Senior/Freshmen differences in design processes



Source: Atman, Cynthia J., Justin R. Chimka, Karen M. Bursic, and H. L. Nachtmann (1999).

Metacognition:
Applied to your teaching

Think: In what ways could your teaching take into account metacognition? (2 min)

Pair: Discuss with a colleague (4 mins)

Share: Discuss as a group (4 mins)

Metacognition: Applying to your teaching
Ideas from workshop participants

Ideas....

Recap: Three main findings from "*How People Learn*"

- Students have preconceptions
- Knowledge organization matters
- Students benefit from a "metacognitive" approach to instruction

Source: National Resource Council, How People Learn: Brain, Mind, Experience, and School, (2000)

Going Forward:

Think: Think about the topic you will teach with respect to the research findings from “How People Learn” Think about one research result you may try to implement (2 min)

Pair: Discuss with a colleague (4 mins)

Share: Discuss as a group (4 mins)

What result could you implement?
Ideas from workshop participants

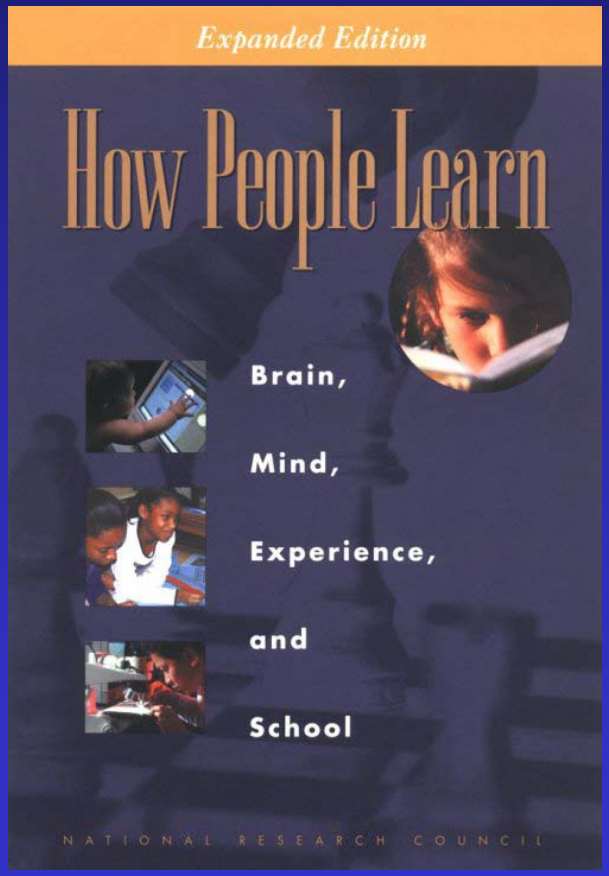
Ideas...

Revisiting Workshop Goals:

1. Explore research results on how people learn
2. Think about ways these results might be applied in the context or your own classroom

Good Luck!

"*How People Learn*"



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