Understanding how people learn science…
On the importance of navigating around expert blind spots, homogenous views of learners & content obsessions

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Overview of the talk…

- The nature of *disciplinary expertise*
- *The constructive nature of knowing*
- A bit about *metacognition & learning*
- So, what can we do to support learning?
  - *Disciplinary expertise, revisited*
  - Shaping *social and material experiences* for learning
  - Help students learn science through *argumentation & debate*
- A bit about *our "science of learning" center (LIFE)*
- Some *research gaps* about human learning

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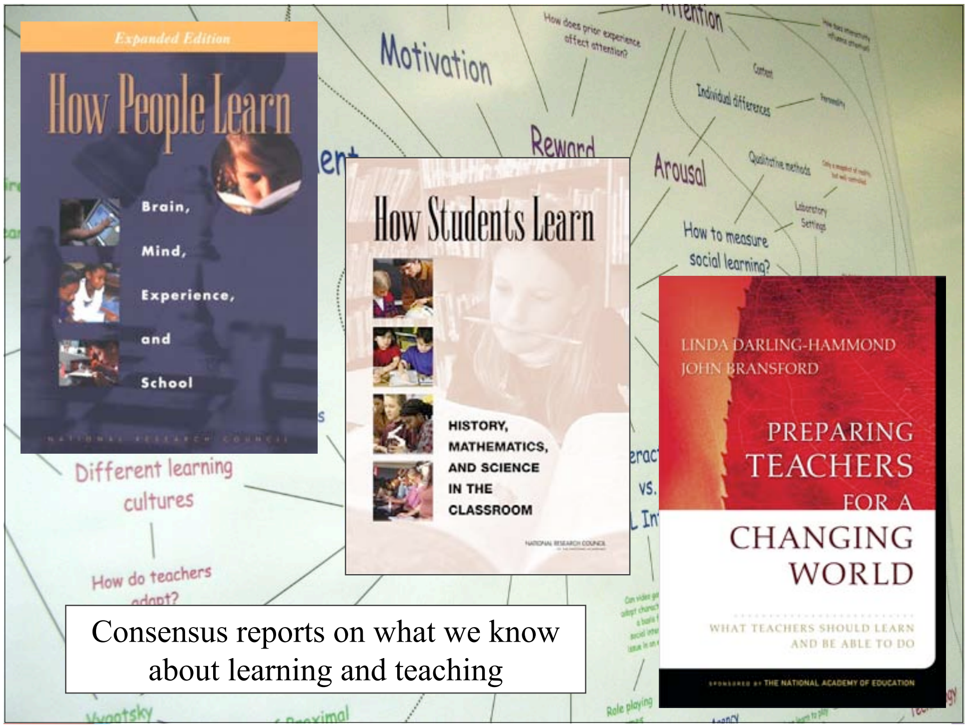
Expanded Edition
How People Learn
Brain, Mind, Experience, and School
How Students Learn
HISTORY, MATHEMATICS, AND SCIENCE IN THE CLASSROOM
LINDA DARLING-HAMMOND
JOHN BRANSFORD
PREPARING TEACHERS FOR A CHANGING WORLD
WHAT TEACHERS SHOULD LEARN AND BE ABLE TO DO
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Motivation
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How to measure social learning?
Different learning cultures
How do teachers adapt?
Consensus reports on what we know about learning and teaching


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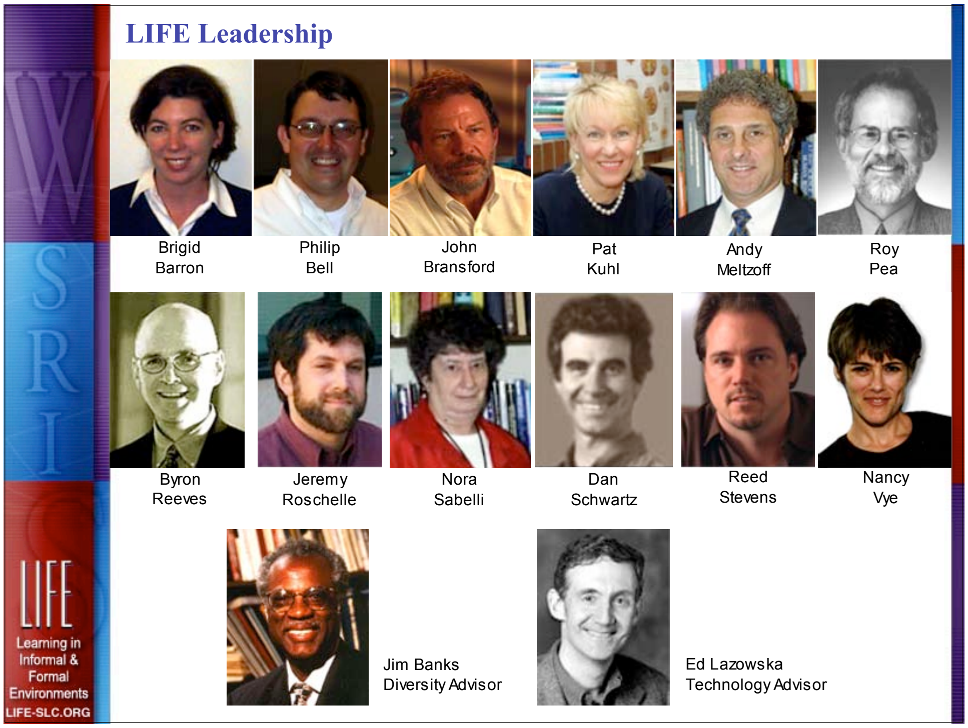
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Brigid Barron
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An image of disciplinary expertise…
From *Apollo 13*…
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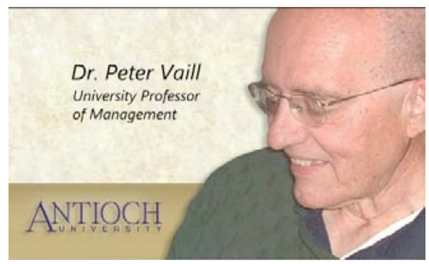
A contrasting image of schooling…

We all too often avoid giving students *agency* for their own inquiry and learning—at school *and* at home



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One of our central challenges…

"In training a child to activity of thought, above all things we must beware of what I will call *inert ideas* — that is to say, ideas that are merely received into the mind without being utilised, or tested, or thrown into fresh combinations."

— Whitehead (1929)

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The nature of expertise
is complex, differentiated,
and, in some ways,
debilitating

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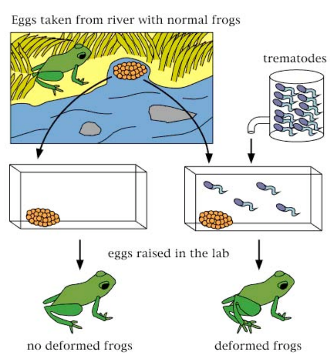
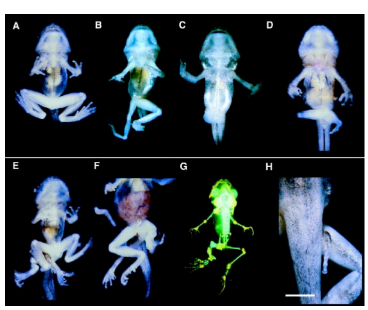
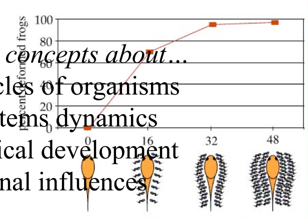
Expertise involves conditional application of complex, specialized knowledge & methods…

Evidence Source:
P. Johnson, K. Lunde, E. Ritchie, A. Launer, in Science. (1999 April 30), vol. 284, pp. 802-4.







Involved concepts about…
- Lifecycles of organisms
- Ecosystems dynamics
- Biological development
- Hormonal influences

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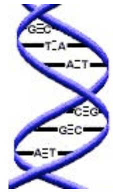
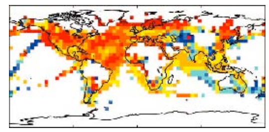
Bringing contemporary science into the curriculum

Deformed Frogs & Declining Amphibians



Genomics: Where do our genes come from?

Treatment & Control of Malaria, Global Ban of DDT

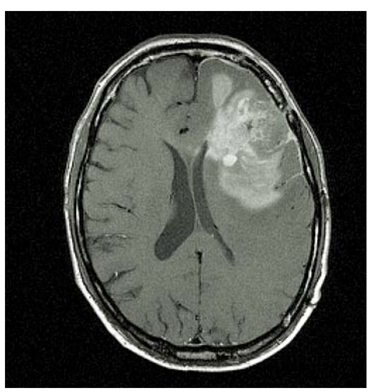


Human influences on global warming

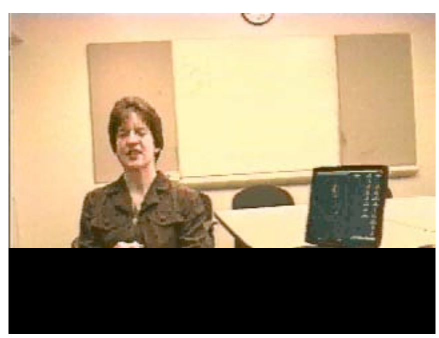
Genetically Modified Foods

DNA Forensics in Human Rights Contexts

Expertise also involves disciplined noticing



The application of technical expertise often requires little attentional effort since it becomes dispositional and automatic



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The Expert Blindspot 'Debilitation'

- Commitment: Educational goals should be strongly shaped by disciplinary knowledge and practices.
- Paradox: Some of the 'most expert' are not the best teachers (HPL, 2000).
- A consequence of expertise is that individuals can lose sight of…
  - aspects of their own conceptual learning and disciplinary practices
  - how their expertise is 'conditionalized' for use in particular situations—and not others
- This aspect of the 'expert blindspot' makes it challenging to identify the conditional knowledge and practices to bring to the learner—and to understand the learning processes of novices.

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But it gets worse…
well, at least more complex

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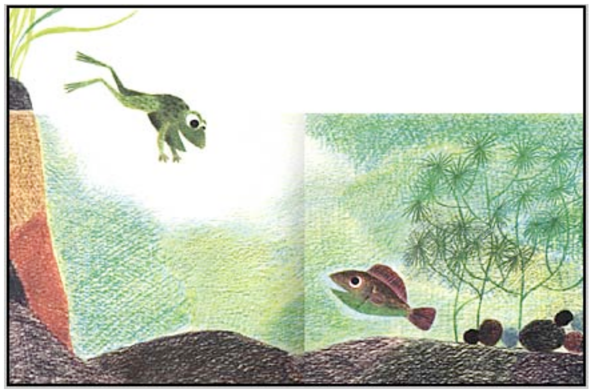
Understanding the nature of learning through *Fish is Fish* (Lionni, 1970)



The fish's images of birds

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The fish's images of cows

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The fish's images of people

Highlights the constructive nature of knowing.
- We build our understanding on what we know.
  - Language is frequently ambiguous and conflicting.
    - It highlights another face of the expert blindspot.

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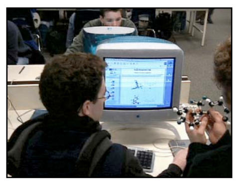
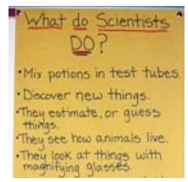
Understanding involves integrating many sources of information into coherent whole

How do people make sense of the *images of science* they encounter…





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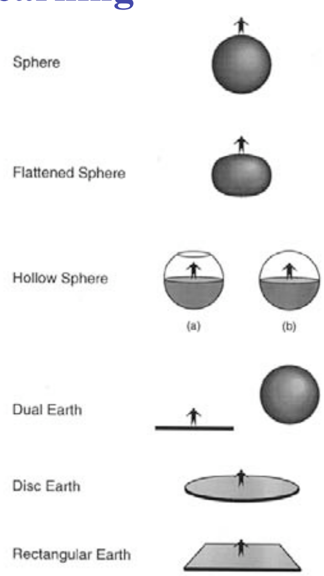
This constructive nature fuels the "misconceptions" view of learning

Conceptions Literature (~6k studies, *Students' and Teachers' Conceptions and Science Education* database, R. Duit)

What is the shape of the earth?
Children have wildly different models (Vosniadou & Brewer, 1992)

Misconceptions Reconceived (Smith, diSessa & Roschelle, 1992) argues for…
• a *conceptual ecology / pieces* perspective (concepts, intuitions, narratives, facts,…)
• *knowledge refinement of pieces* is a more productive view than *replacement of models* because of constructive nature of learning
• prior knowledge exists for a reason



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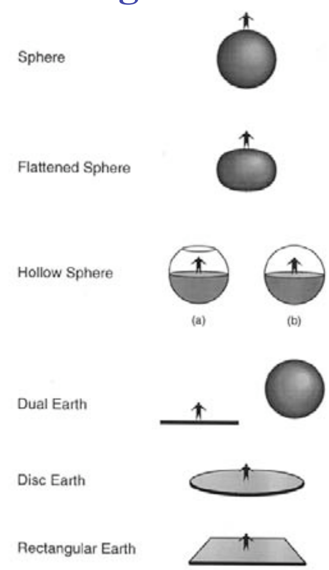
This constructive nature fuels the "misconceptions" view of learning

How quickly should students settle on a scientific concept?
…a day?
…a month?
…a year?
…a decade?

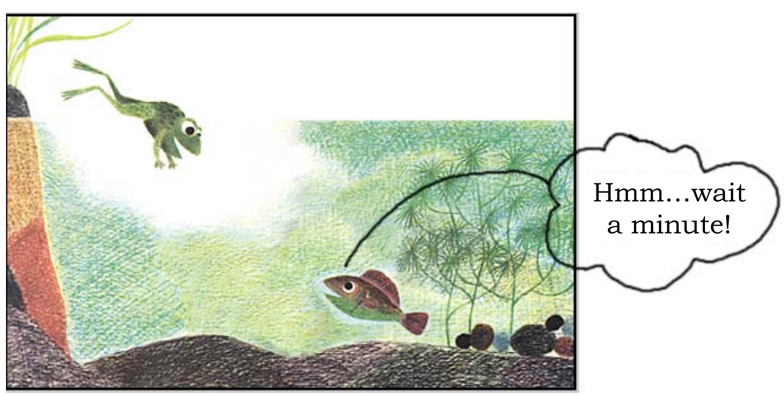
Many educational approaches demand (or assume) quick conceptual learning

But, some science educators believe that 'content obsessions' are at odds with students engaging in and learning about scientific inquiry and thinking

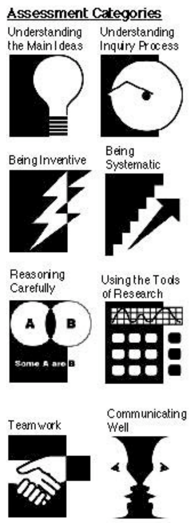
That is, that process is more educationally important than quick understanding



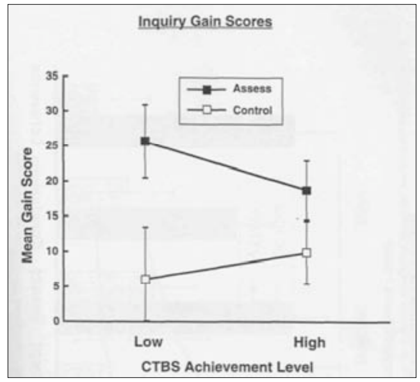
Encouraging metacognition helps… (i.e., thinking about thinking and learning)



Metacognitive self-assessments promote conceptual learning & understanding of inquiry



Students were asked to design and analyze a hypothetical study



White, B., & Frederiksen, J. (2000). Metacognitive facilitation: An approach to making scientific inquiry accessible to all. In J. Minstrell and E. van Zee (Eds.), Inquiring into Inquiry Learning and Teaching in Science. (pp. 331-370). Washington, DC: AAAS.

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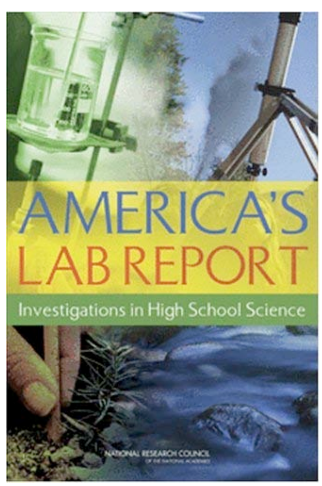
New report from the NAS…



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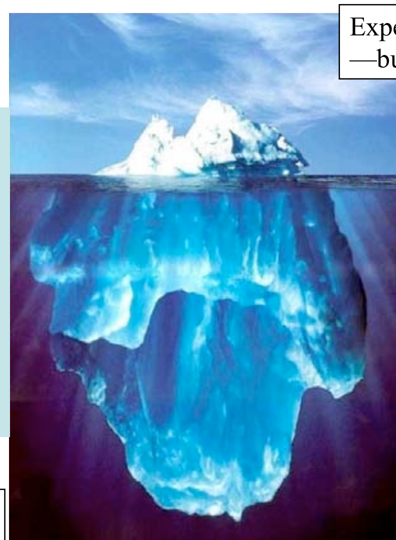
So, the Challenge: Getting to Know What Students Know & Supporting Refinement

Learning

Experiences afford learning —but don't dictate it



Learner Behavior (What they say & do)		Educational Experiences
inadequately represents		is often thinly represented in
Prior Knowledge (What they know)		Disciplinary Expertise

And students frequently have different 'icebergs'

Norman (1982)—"The Two Icebergs"

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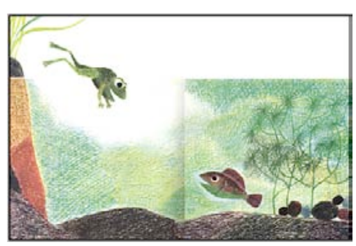
So, what do we do?
First, we should recognize that science learning is heavily influenced by *social interactions* and *material engagement*



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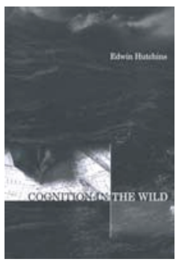
A broader view of expertise… as socially and materially distributed

- Expertise can be understood as competent, coordinated activity *amongst a group* in *a material context*. But, understanding is often assessed in school through sequestered problem solving.
- Workplaces are often being configured in today's economy with geographically dispersed, collaborating teams.



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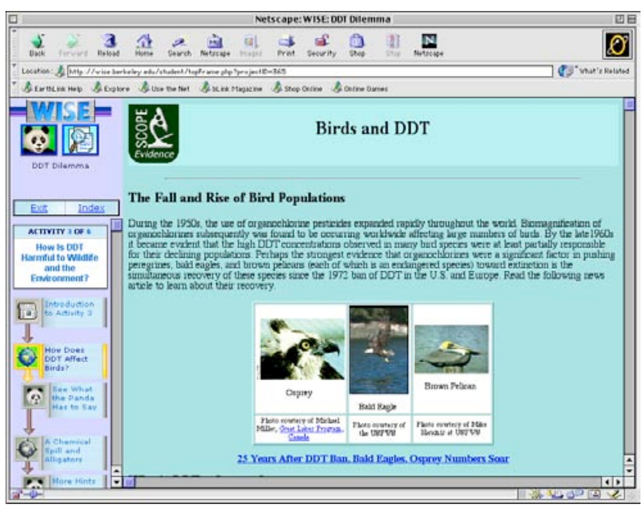
Web-based Inquiry Science Environment (WISE) - wise.berkeley.edu



the learning environment makes individual and social learning mechanisms more likely

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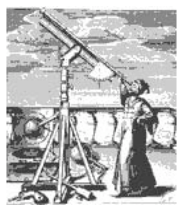
Some of my prior research has focused on middle school students learning about light



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The Intervention: The "How Far Does Light Go?" Debate Project

- A comparison of two theories:
  - Light dies out as you move farther from a light source.
  - Light goes forever until absorbed.
- Student activities:
  - Analyze, categorize, and create evidence
  - Create argument involving evidence and claims
  - Present and discuss their argument in class

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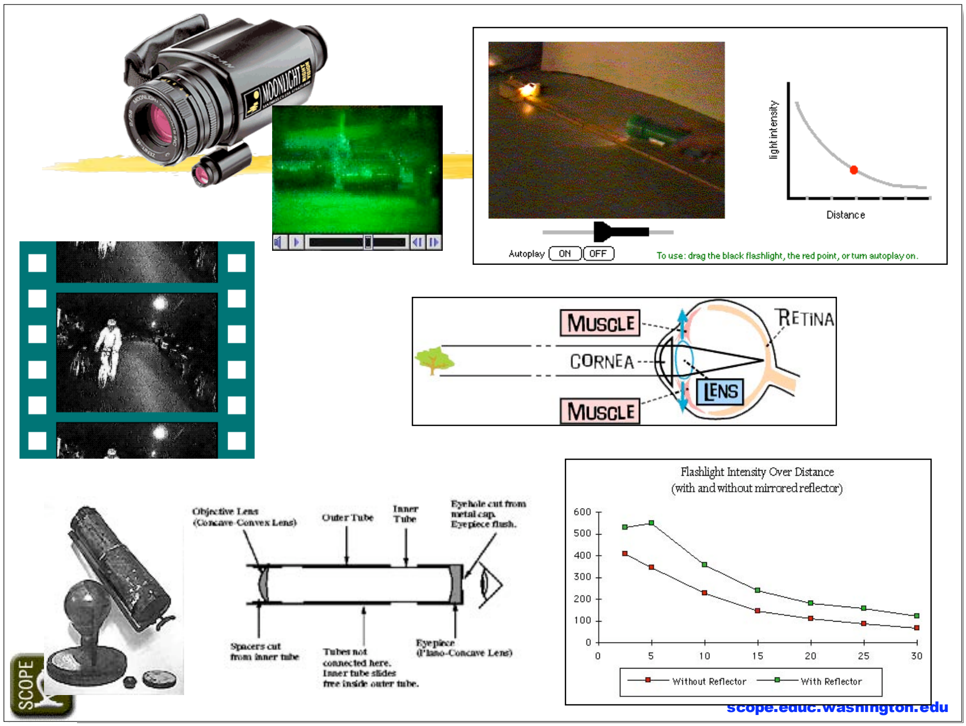
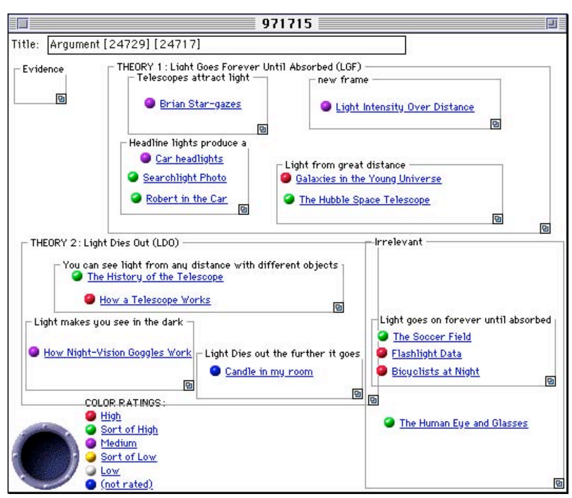


Social supports for learning through argumentation and debate

- Social activity structures which are *cyclical* and *'forgiving'* (i.e., safe) can support learning by…

Making student thinking visible

Promoting shared understanding



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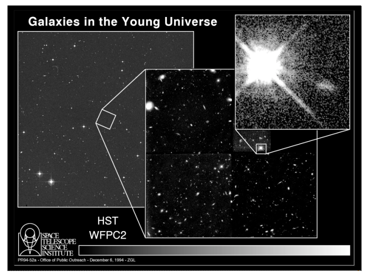
Footnote: Sarah's idea about telescopes…

- *In explaining how telescopes work…*

  "… with a telescope you're seeing farther away. So the light would die out eventually because you can't see that, so you have to look farther out to get the light that's farther out because it's died out before it's got to us."

- *Telescopes look at light closer to the light source*
  - A strongly held idea for Sarah that she was still wrestling with after two weeks



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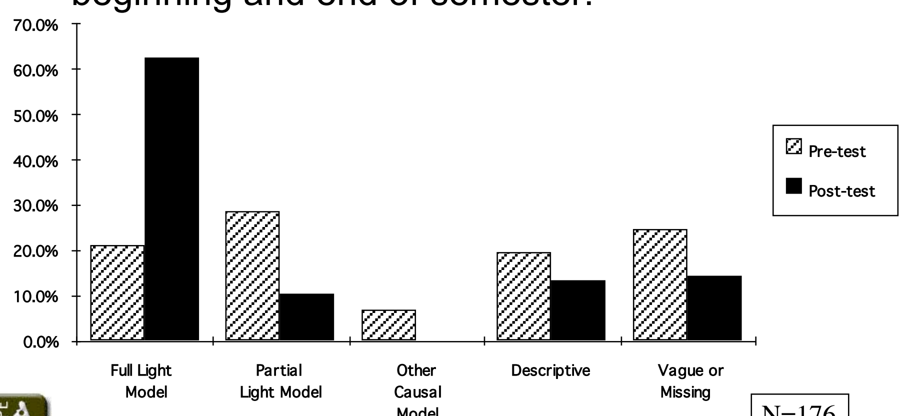
Individual Conceptual Change about Light Propagation

- From cognitive assessments administered at the beginning and end of semester:



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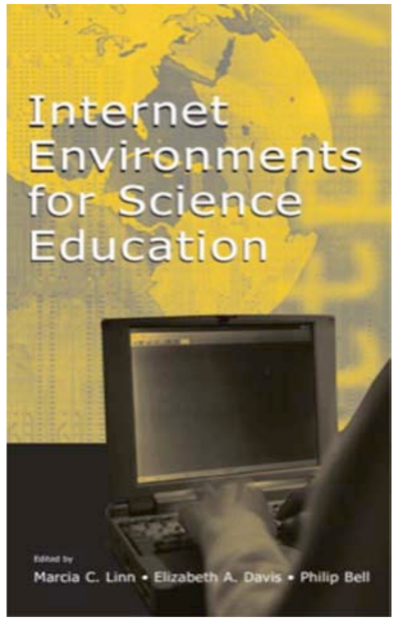

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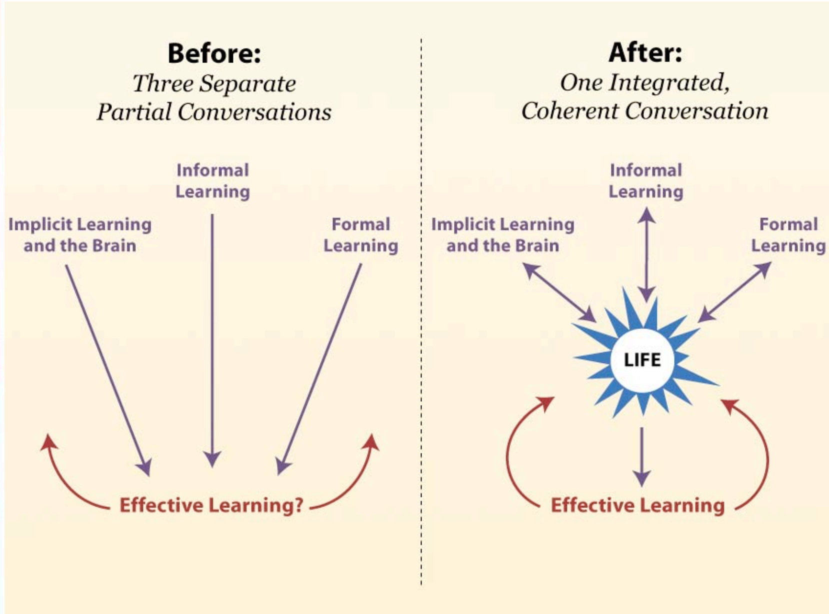
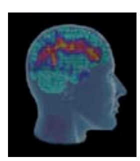
LIFE: Learning in Informal & Formal Environments

A Schematic of LIFE's Vision



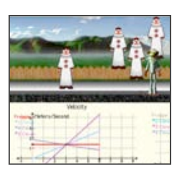
LIFE research strands have own language, theory, and methods—need sustained conversation

Implicit: social cognition, neural commitment, imitation, early learning, representation

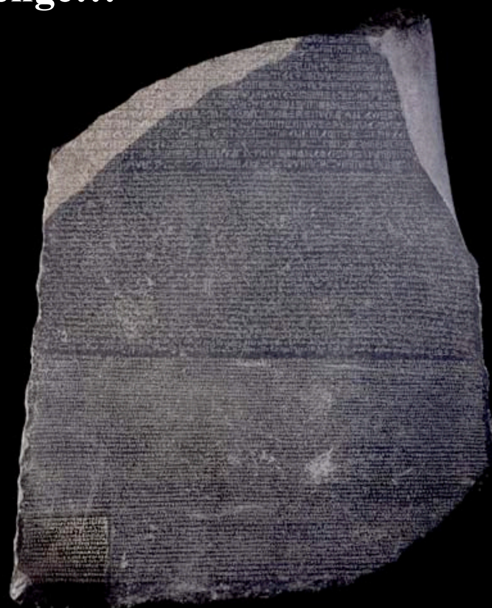


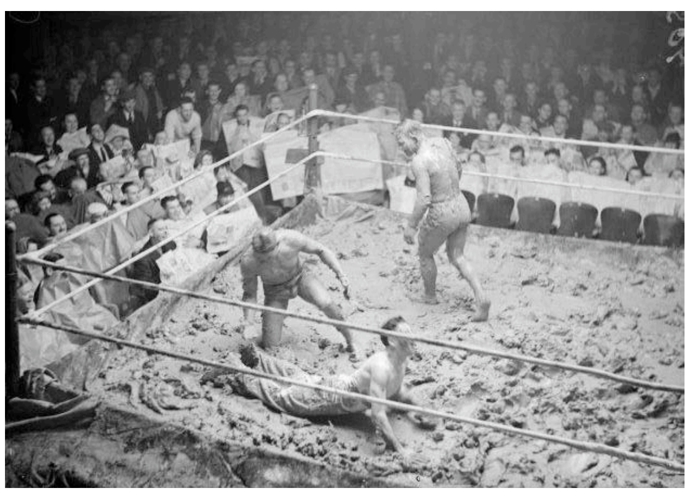

Informal: context, distributed participation, interaction, appropriation of tools, culture, improvisation


Formal: transfer, preparation for future learning, adaptability, efficiency, design of tools




Our challenge…





Mix it up! Our early conceptual collisions are expected to be a little inexact and messy

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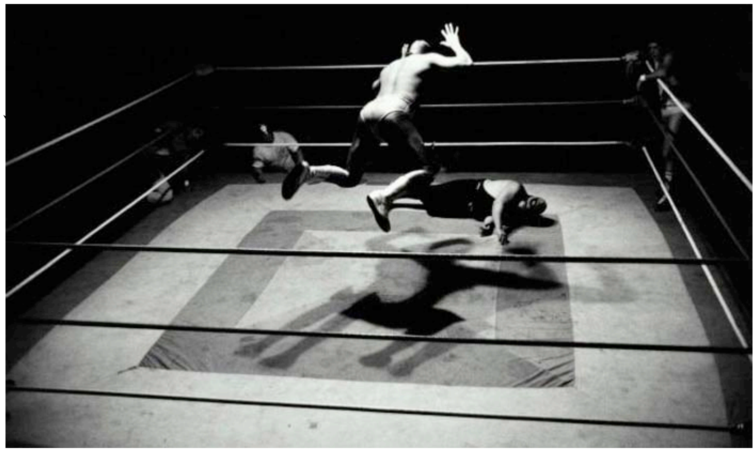

More refined collisions are expected over time

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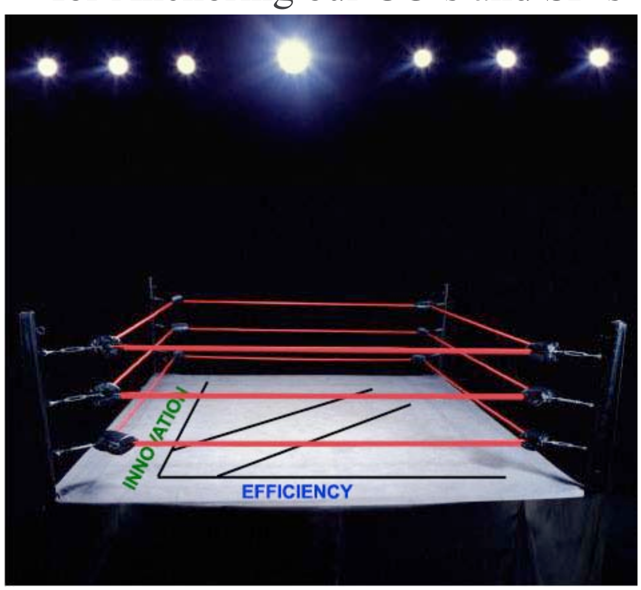
A New Conceptual Framework
for Anchoring our CC's and SP's



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Methodological approaches in the learning sciences: A quick tour

What, to whom, and how?

- "The master question from which the mission of education research is derived: What should be taught to whom, and with what pedagogical object in mind? That master question is threefold: what, to whom, and how? Education research, under such a dispensation, becomes an adjunct of educational planning and design. It becomes design research in the sense that it explores possible ways in which educational objectives can be formulated and carried out in the light of cultural objectives and values in the broad."

  — Jerome Bruner, *Issues in Educational Research* (1999)

- Allied disciplines with the learning sciences…
  - Cognitive psychology — Developmental psychology
  - Sociocultural anthropology — Computer science
  - Micro-sociology — Applied sociolinguistics
  - Cognitive neuroscience — STEM disciplines

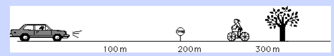
Pursuing Learning Questions

- What are students learning? Are they learning? What are their conceptual ideas (over time)?

METHODS:

– Cognitive assessments

A car approaches a bike rider at night, 250m away. Its headlights are "dimmed". The bike rider sees the headlights of the car.



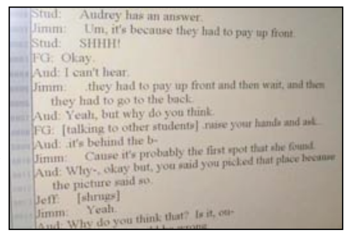
a. How far does the car's light travel? (circle one)
The light will not reach the stop sign
To the stop sign, but not beyond
To the bike rider, but not beyond
To the tree, but not beyond
Beyond the tree

b. What is the most important reason for your answer?

– Task performances (protocol analysis)

– Clinical interviews

– Analysis of student talk (interaction analysis)



Stud: Audrey has an answer.
Jimm: Um, it's because they had to pay up front.
Stud: SHHH!
FG: Okay.
And: I can't hear.
Jimm: ..they had to pay up front and then wait, and then they had to go to the back.
Aud: Yeah, but why do you think.
FG: [talking to other students] ..raise your hands and ask.
Aud: ..it's behind the b-
Jimm: Cause it's probably the first spot that she found.
Aud: Why-, okay but, you said you picked that place because the picture said so.
Jeff: [shrugs]
Jimm: Yeah.
Aud: Why do you think that? Is it, ou-

Pursuing Context Questions

- What is going on here? How are students learning? What do students think this is about? From student's lived experiences, what relates to their present learning?

METHODS:

– Systematic observation; ethnography

– Ethnographic interviews

– Surveys

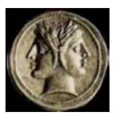
Pursuing Teaching Questions (aka the Engineering of Learning)

- How can individuals learn? How can groups accomplish complex tasks—learn to be collectively intelligent? How can disciplinary 'habits of mind' be cultivated over years?

  METHODS:

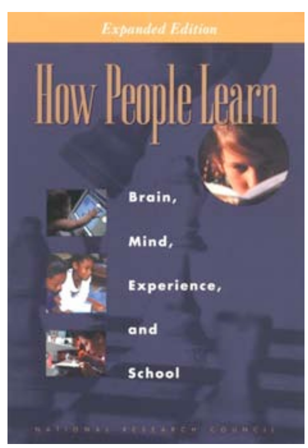
  - Design-based research / "Teaching as research"
  - "As a design scientist in my field, I attempt to engineer innovative educational environments and simultaneously conduct experimental studies of those innovations. This involves orchestrating all aspects of a period of daily life in classrooms, a research activity for which I was not trained."

— Ann Brown (1992)

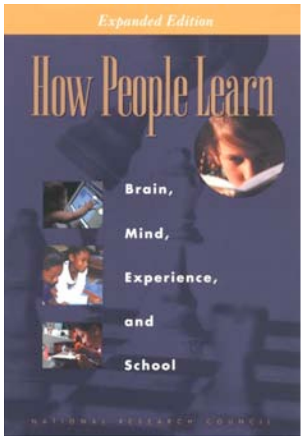


Improving educational outcomes of interest
while
Developing a better understanding the conditions under which education-phenomena can be sustained

What should the 2015 edition look like?



Some Underemphasized Research Areas…



- The gap between the natural sciences and science education seems to be widening
  - Specific disciplines / fields get variable coverage
  - Multi-, inter-, trans-disciplinary research largely ignored
  - Lemke: “The Missing Context of Science Education: Science”

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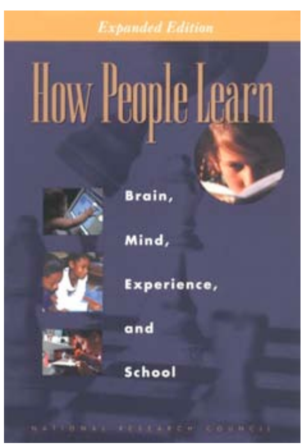
Some Underemphasized Research Areas…



- Children spend 80% of the time they are awake outside of the classroom
- Understanding how children learn science outside of school…
  - in science centers
  - at home with their families
  - in peer groups
  - online
  - from media

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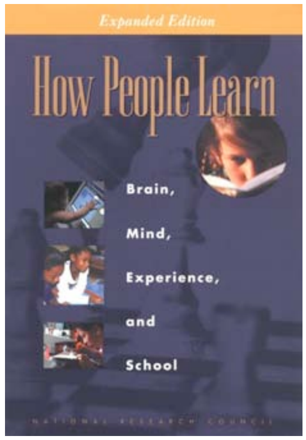
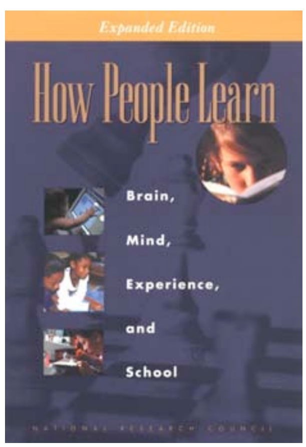
Some Underemphasized Research Areas…



- The cultural foundations of science learning…
  - What are the educational opportunities associated with differences in class, race & ethnicity? What are the constraints?
  - Achievement improves when schools make stronger links to the home and community (e.g., Moll's research on *funds of knowledge)*.
  - Research indicates that students have sophisticated competencies readily put to use in the home that are not called upon in school (e.g., Heath).

Some Underemphasized Research Areas…



- A comparative understanding across school subjects
  - Strong Claim: Students may more quickly learn to think like a scientist if we get better at teaching them how to think like a historian.
  - We are balkanized by subject areas.
  - Children learn across subjects.
  - We need to help students make sense of the similarities and differences between disciplines.

Stevens, R., Wineburg, S., Herrenkohl, L. R., & Bell, P. (2005). The comparative understanding of school subjects: Past, present, and future research agenda. *Review of Educational Research*, *75*(2), 125-157.

In closing, this is what we are hoping to avoid through our studies of learning…

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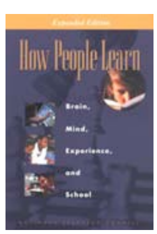
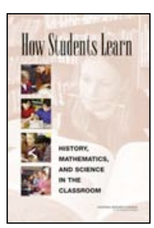
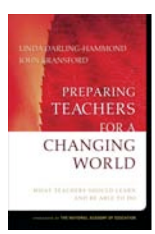
Thank you!

- For more information on this work…
  - **http://everydaycognition.org/** (my research group)
  - **http://life-slc.org/** (The LIFE Center)
  - **http://isls.org/** (Int'l Society of the Learning Sciences)
  - **pbell@u.washington.edu** (me)

  - National Academy Press — **http://www.nap.edu/**







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