Interactions between the Art & Science of Physics Learning-Teaching

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"Instruction begins when you, the teacher, learn from the learner, put yourself in his place so that you may understand what he understands and in the way he understands it,…"

The Point of View for My Work as an Author

Soren Kierkegaard (1848)

Copied from Facebook

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"We must learn to be more receptive to responses, more sensitive to viewpoints of those we try to reach."

Melba Philips, 1974

AIP

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Richard Feynman: BBC Horizon "The Pleasure of Finding Things Out." (1981)

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The Feynman Lectures on Physics.

. . . As the course wore on, attendance by the kids at the lectures started dropping alarmingly, but at the same time, more and more faculty and graduate students started attending, so the room stayed full, and Feynman may never have known that he was losing his intended audience.

David Goldstein
Physics Today February 1989

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Feynman Effect

… directing one’s teaching toward colleagues when one is supposed to be focusing on freshmen. This situation arises when one allows one’s pedagogy to be guided by the perceived standards of ones professional peers rather than by a realistic understanding of … the abilities on one’s students.

Al Bartlett
Physics Today January 1992

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Students start their study of physics with a lot of knowledge of the physical world

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Research
Difficulties, Misconceptions & Models

- Student difficulties in specific areas
  - e.g. Research by McDermott *et. al.,*
- Conceptual Assessments
  - e.g. Force Concept Inventory etc.
- Investigating mental models
  - e.g. Model Analysis by Bao.

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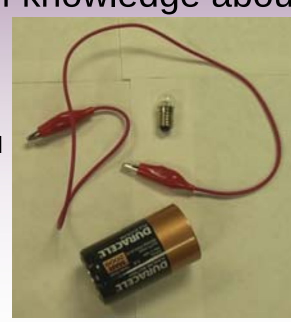
Thanks to Sanjay Rebello

Pre-conceptions about pre-conceptions

- Battery-bulb interview exercise
  - With a light bulb, battery and a wire, get the bulb to turn on
  - Failure interpreted as lack of knowledge about complete circuits



Alternative interpretation
- Students do not know how the light bulb is wired
- "The light bulb is a complete circuit in itself."

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Engelhardt, Gray & Rebello (2004)

Modeling Conceptual Change

- Cognitive Conflict
  - e.g. Posner *et. al*.
- Incremental Approaches
  - Ontological change - Chi *et. al.*
  - Hierarchical change - Thagard *et. al.*
- Resource Activation e.g. Hammer
  - Incremental, cascade, wholesale, dual construction - Wittmann.
- Combination
  - Blending - Fauconnier & Turner.
  - Hybridization - Hrepic.

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Shift in our thinking about student thinking

- Knowledge in pieces rather than coherent mental model.
- Difficult to probe student knowledge without affecting it.
- Focus on dynamics of knowledge transfer & construction rather than state of knowledge - learning.

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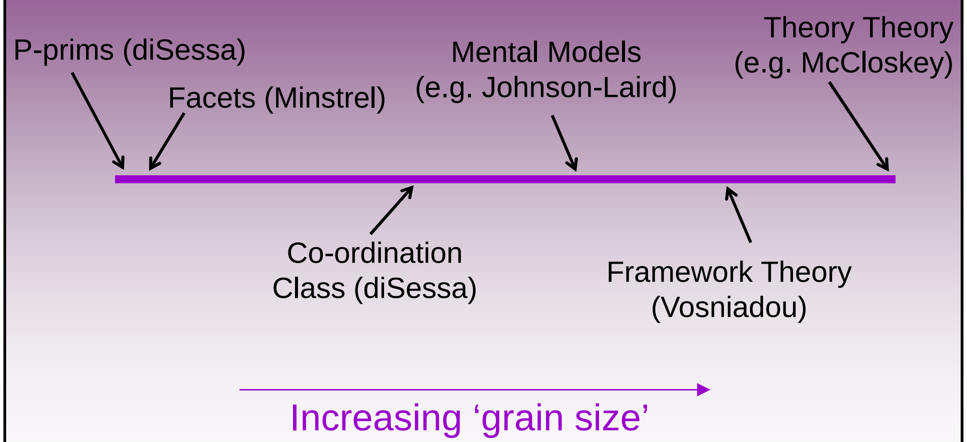
Research

Knowledge Structures



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Questions

- What do students know?
- How does what they know affect their learning?
- How do they process new information as they learn?
- How do interactions with others affect learning?
- How does learning transfer from one place to another?
  - Everyday ⟷ Classroom
  - One topic ⟷ Another
  - One class ⟷ Another

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Teaching/Learning Interviews

- Attempt to change students' ideas
  - Provide a rich environment for learner to interact with
  - Provide scaffolding through hints and cues
  - Interviewer is both researcher & facilitator of learning
- Types:
  - Individual vs. Focus Group

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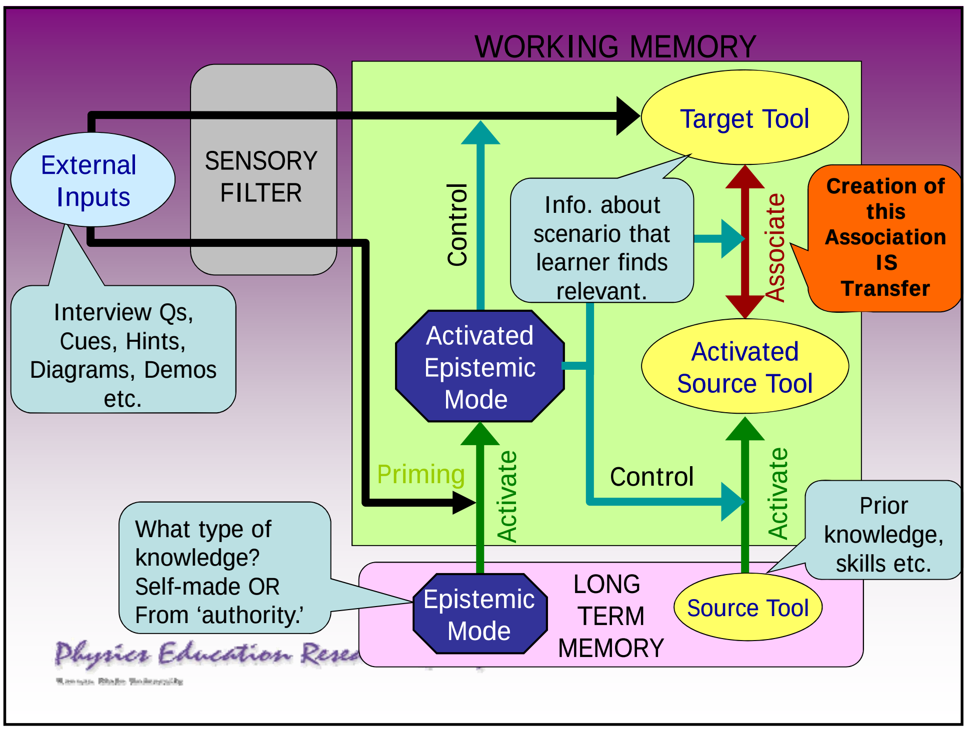

Dynamic view of how students

- Process during the learning of physics
- Interact with each other to help the learning process
- Activate their “resources” during learning
- Utilize scaffolding while learning

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In a physics problem solving situation

- What underlies the students’ expression of conceptual understanding?
- Do students make it up as they go?
  - If so, what are the “building blocks” that they use?
- How do beliefs about knowledge affect what they do?
- Are social interactions important?
- Are misconceptions a necessary step in the process?
- How can interactions with teacher & students make the process more efficient?

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What do teachers add (or subtract)?

AAPT

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Teacher or teaching in AJP titles or keywords

- A study of pre- and inservice physics teachers' understanding of photoelectric phenomenon as part of the development of a research-based quantum physics course (2009)
- Categorization of problems to assess and improve proficiency as teachers and learners (2009)
- Improving the preparation of K-12 teachers through physics education research (2006)
- A brief primer on tamped fission-bomb cores (2009)

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Casual Conclusion

- Focus on other teachers
  - Inservice
  - K-12
  - …
- But not ourselves

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Building on student knowledge

- Piaget's Model of Intellectual Development
  - Introduced to the physics community by Karplus & Renner
- Led to research on student conceptual understanding
  - Pre- and post-instruction
- "We must learn to be more receptive to responses, more sensitive to viewpoints of those we try to reach."
    - Melba Philips, 1974

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Researching Student Understanding

- Focus on one or a very few concepts
- No preconceived idea of students' conceptions
- Build generalizations from students' responses
- Clinical interview
  - One-on-one with a researcher
  - Small numbers

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Mis-, pre-, alternative- conceptions can be addressed by instruction

- Interactive engagement seems to work
  - A variety of formats have been effective
  - Active student involvement important
- Traditional lecture effectiveness is limited
- All students seem to benefit
- Multiple modes of instruction may be best
  - Not yet thoroughly investigated

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We’ve Come a Long Way

- Conceptual difficulties well documented
  - In essentially all areas of physics
- Instructional methods established
  - Can address the difficulties well
  - Widely but not universally adopted
- Contextual dependence investigated
  - Probably quite important
- Diversity issues explored
  - But need much more attention

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Why did (does) anyone succeed at learning physics?

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