



Why are Some Science and Engineering Concepts so Difficult to Learn? Identifying, Assessing, and “Repairing” Student Misunderstanding of Important Concepts

Ruth Streveler (CSM), Barbara Olds (CSM), Mary Nelson (CU-Boulder),
Ron Miller (CSM)



Workshop Overview

- What science and engineering concepts seem to be most difficult for students to learn?
- Why some concepts are so difficult to learn
- Some ways to measure students' misunderstanding of these concepts.
- Some ideas for designing instruction to make these concepts easier to learn



What science and engineering concepts are most difficult?

➤ Participant introductions

- Participants team with those in related fields

➤ Exercise

- What concepts do the students you are most difficult to learn?
 - Individually write down answers (2 minutes)
 - Share with your team (6 minutes)
- Report back to the whole group



Why are these concepts
difficult?



From the Video...

"Sometimes the simplest problems in science defy intuition and the most basic technology is surprisingly difficult to grasp. Is it because we weren't taught? Or is it because of something deeper? Something about the way we think?"



What is a Misconception?

- In terms of a constructivist view of learning and knowledge, students create mental models describing their view of the world
- Models which inaccurately describe phenomena are termed misconceptions or alternate conceptions



Misconceptions and Prior Knowledge

- Students come to your classes with at least partially developed mental models which we may term prior knowledge
- Prior knowledge is often formed using everyday experience and may involve significant, robust misconceptions



How can misconceptions be identified?

➤ Research methods

- interviews
- "think aloud" problem-solving
- verbal protocol analysis

➤ Concept inventories

- multiple choice instruments with conceptual questions (answer list includes common misconceptions as distractors)



A Concept Inventory Exercise

- Individually, complete the 4 question concept inventory (2 minutes)
- Your team compare answers; develop a consensus answer for each question (5 minutes)
- Be prepared to report to the full group



Concept Inventories Promote Learning

- Understanding misconceptions is an essential component of pedagogy
- Students will cling to misconceptions unless these fallacies are addressed

Shulman, 1986



Expert Blind Spot (EBS)

- EBS is the “inability to perceive the difficulties that novices will experience as they approach a new domain of knowledge that arises as a consequence of well-developed subject matter knowledge.” Nathan, Koedinger and Alibali, 2001
- Concept inventories are designed to identify those micro-level difficulties that teachers sometimes overlook because of EBS.



Importance of Identifying Misconceptions

- Concept inventories help teachers to focus on the prior knowledge that students bring to their classes.
- Included in this prior knowledge may be strongly held misconceptions.



Some Guidelines for Repairing Misconceptions

- Think about the **conceptual** knowledge you want students to acquire
- Use methods to uncover student pre- or misconceptions of these concepts
- Allow students to “experiment” with the concepts
- Help students construct a new conceptual framework for understanding these concepts
- Find ways to gather feedback about students' understanding



Helping students construct a new conceptual framework

- Help students visualize the process
 - Periodic table exercise
 - Moles = amount not mass using small balls and large balls
 - eChem simulations
- Ask students questions about their conceptions
 - Explain, justify
 - WHY does this happen?
 - Focus on concepts and situations, not equations



Misconception Activity

- List as many misconceptions in your discipline as you can think of (3 min.)
- Share your list with your team and select one important misconception (5 min.)
- Discuss how you might identify the misconception and how you might design a course unit to repair it (10 min.)



Our Current Projects

- Developing an Outcomes Assessment Instrument for Identifying Engineering Student Misconceptions in Thermal and Transport Sciences (NSF DUE-0127806)
- Center for the Advancement of Engineering Education (NSF ESI-0227558)



For more information

➤ Check the CSM Center for Engineering Education website

- www.mines.edu/research/cee/misconceptions

➤ Check CAEE web site

- <http://www.engr.washington.edu/caee/>

➤ Website of Michelene Chi

- <http://www.pitt.edu/~chi>