Conceptual Knowledge

• Conceptual knowledge: “understanding of principles governing a domain and the interrelations between units of knowledge in a domain” (Perkins, 2006)

• Organization of conceptual knowledge: (Ozdemir & Clark, 2007)
  • Knowledge as theory
  • Knowledge as elements

• Misconceptions, misconceptions, misconceptions...

"It’s not what you don’t know that hurts you. It’s what you know that ain’t so!"
Mark Twain
Concept Inventories

• First developed in physics to assess conceptual understanding of force and motion
  • Mechanics Diagnostic (Halloun & Hestenes, 1985)
  • Force Concept Inventory (Hestenes et al 1992)

“Conventional physics instruction produces little change in [common sense misconceptions about mechanics] ... independent of the instructor and the mode of instruction”
  (Hestenes et al 1992)

• Since the Force Concept Inventory, concept inventories have been developed in a wide-range of topics: statics, thermal & transport sciences, circuits, statistics, material science, ...

• Recent work has also suggested several ways to improve the usage of concept inventories (e.g. Steif & Hansen 2007)
Oral Interviews and Exams

• Oral interviews (formative) or exams (summative) can provide rich information about how a student is thinking

• Useful to help identify misconceptions (important tool for the development of concept inventories)

• Can be time consuming and difficult to scale to large classes

• Improves likelihood of an accurate assessment by its dynamic nature

• Valuable, authentic experience for students

• Approximately half of our department’s undergraduate courses use some form of oral assessments
Concept Questions & Peer Instruction

• Concept questions:
  • Focus on a single concept
  • Typically multiple choice
  • More than one plausible answer based on common misconceptions

An example from fluid dynamics on the concept of irrotationality:

Which of these flows are irrotational?

• Concept-based active learning (Peer Instruction, Mazur, 1997)
Active Learning: Twice As Effective as Lecturing

Student Preparation: Look-ahead Homework

(Darmofal, 2005)

- Initial implementation of concept-based lectures only gave reading assignments
- Switched to look-ahead homework due prior to discussing concepts in lecture

**Typical student comments:**

“I was initially opposed to the idea that I had to do reading & homework before we ever covered the subjects. Once I transitioned I realized that it made learning so much easier!!”

“Doing homework before the lectures is good… makes actual learning in lectures possible.”