Reform efforts in introductory physics at Georgia Tech

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Georgia Institute of Technology

NSF

Focus of Reform

- Curriculum
- Computation
- Cognitive Science

} Measurement

Introductory Physics @ Georgia Tech

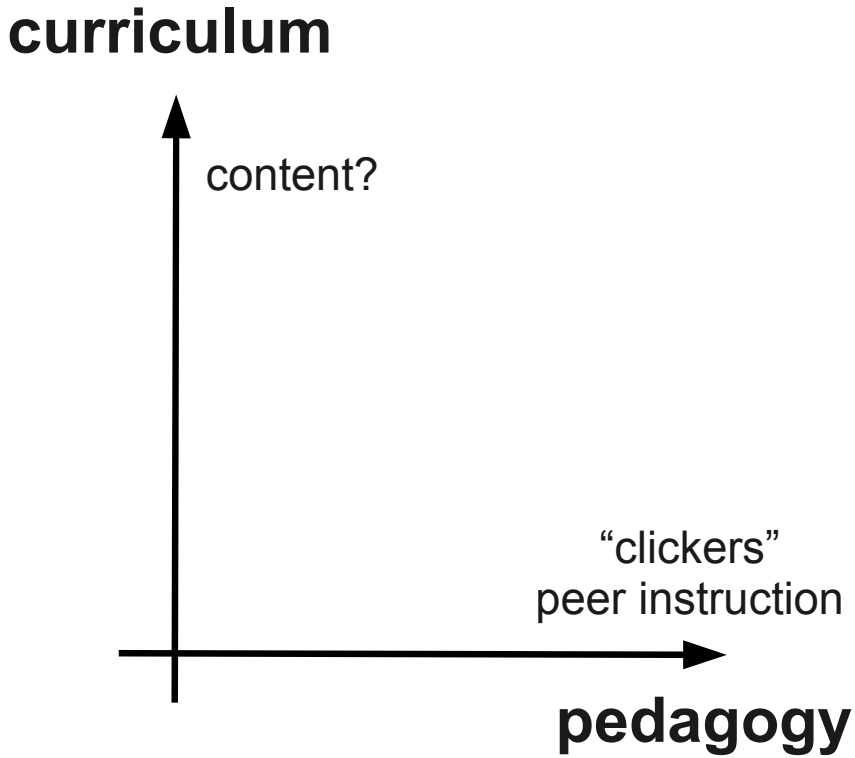
Two Semester (Calculus-Based) Sequence

- Semester 1 – Mechanics
- Semester 2 – Electromagnetism

Boundary Conditions for Intro. Physics

- $\sim$ 1600 students per semester
- 83% engineering, 17% science majors
- 3 hours of Lecture (150-250 students)
- 3 hour Lab/Recitation (25-40 students)

Reforms in Introductory Physics



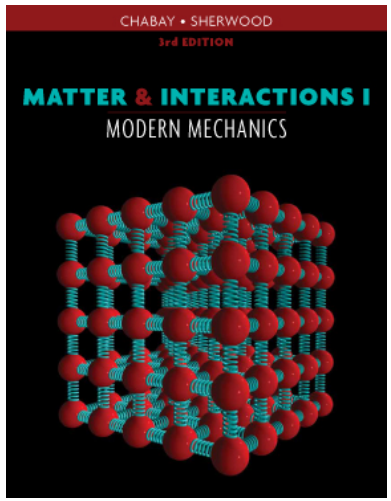
Traditional (TRAD) Introductory Physics

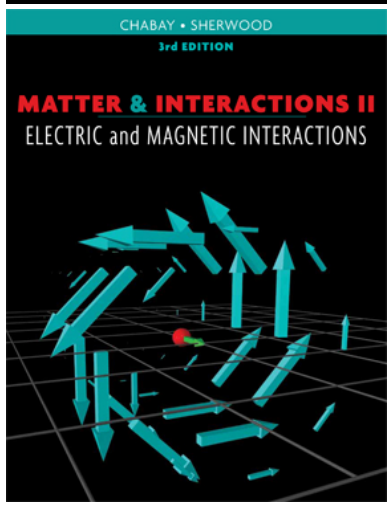
- Content largely unchanged for decades
- Focus on analytic solutions of special cases

Curriculum: Matter and Interactions (M&I)

Modern content

- Fundamental principles
- Atoms and structure of matter
- Relativity and quantum physics
- Macro/micro connections





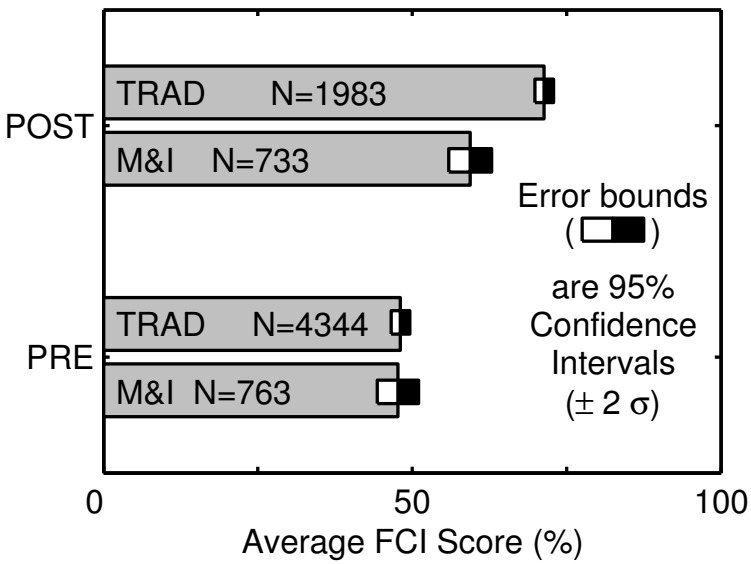
Modern tools/techniques

- Computer modeling
  –Visual Python (VPython)

R. Chabay & B. Sherwood, Wiley, 2010
www.matterandinteractions.org

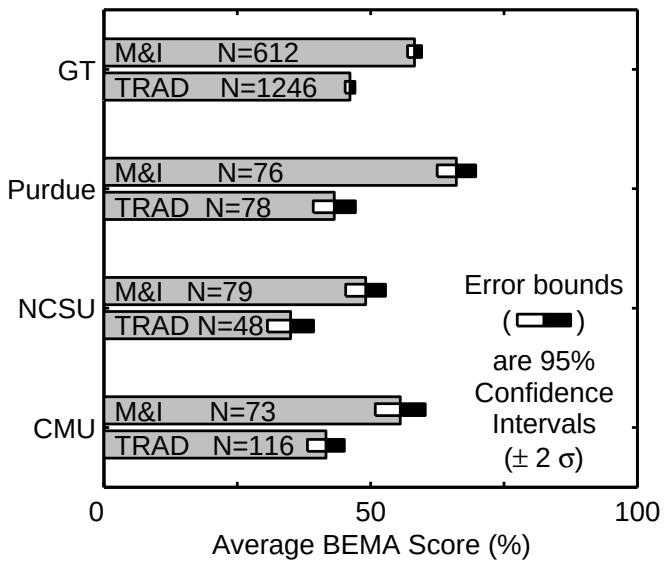
Measurements of Curricular Impact

Mechanics (FCI)



TRAD Outperforms

E&M (BEMA)



M&I Outperforms

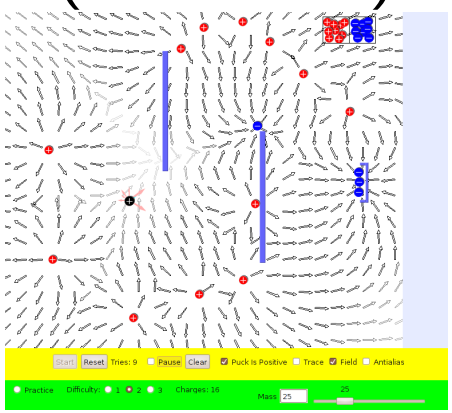
Phys. Rev. ST Phys. Educ. Res. 5, 020105 (2009)

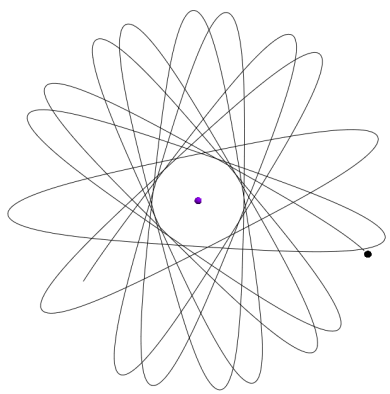
Computational Modeling

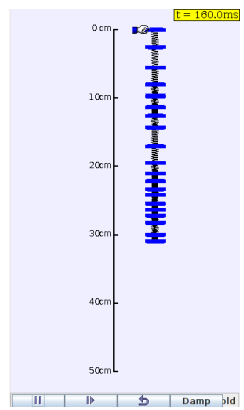
- Third pillar of science and engineering
- Explore "intractable" systems
- Simulate "impossible" experiments
- Visualize the problem

Spectrum of Computational Modeling

PHETs (Colorado) $\Leftarrow$ VPython (GT, NCSU, others) $\Rightarrow$ JAVA (Davidson)







No previous programming experience assumed

Computational Homework Problems

Pilot Semester (N = 520) – Spring 2010

- Homework problems are highly customized per student

Evaluation: Proctored assignment

- $\sim$60% Success rate
- Physics or Syntactic mistakes?

Rethinking Curriculum Design Using Cognitive Science

Think Aloud Protocol Studies

- Individual interview of volunteers who work FCI problems while narrating their thoughts
- $N_{TRAD} = 20$, $N_{M\&I} = 14$

Analysis of interview Audio/Video records

- NO particpants used a fundamental principle

Something is missing

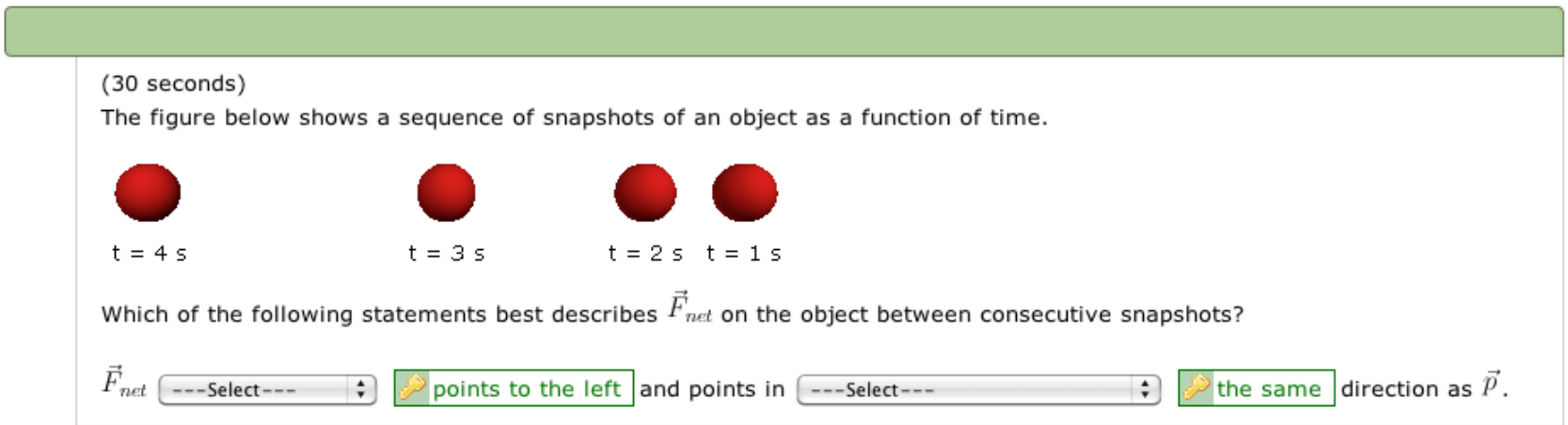
Refocusing the Cognitive Load

Core Skills Development

- Strengthen basic skills to fluency
- Reduce cognitive load

Development & Implementation (Spring 2010)

- Benchtested 300+ exercises
- Basic Skills $\rightarrow$ Complex Skills



The Future of Intro. Physics @ GT

- Curriculum
  - Testing novel curricula in large courses
- Computation
  - Developing computer modeling skills of our students
- Cognitive Science
  - Improving instruction with advances in how people learn