Assessing computer simulations in undergraduate physics lectures, laboratories, and recitations

Chris Keller, Noah Finkelstein,
Katherine Perkins, and Steven Pollock
University of Colorado at Boulder

Acknowledgements

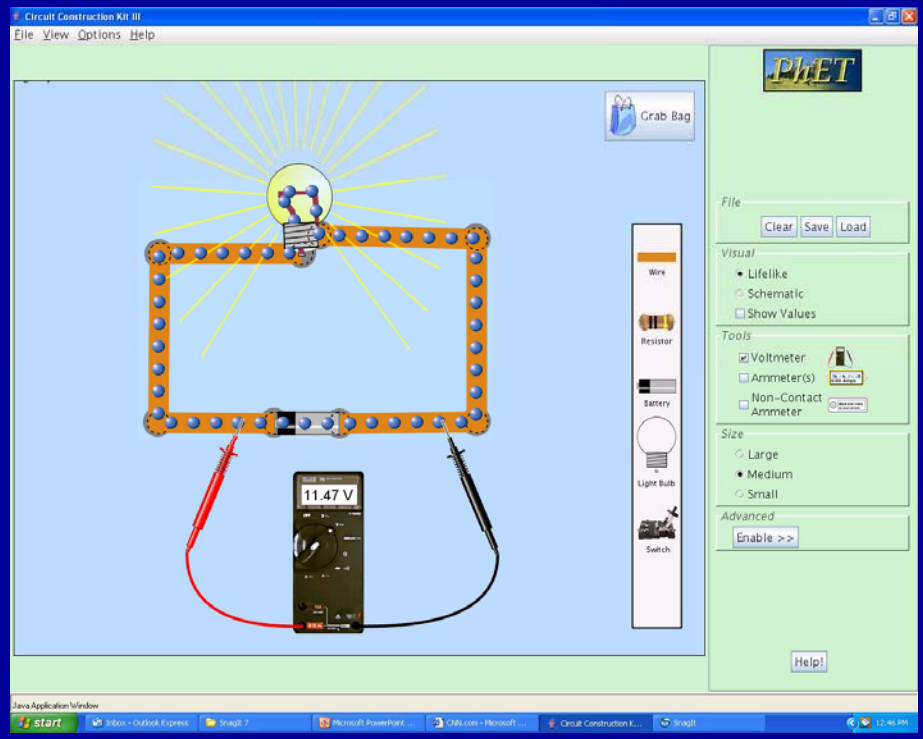
- Physics faculty:
  Michael Dubson
  Noah Finkelstein
  Kathy Perkins
  Steven Pollock
  Carl Wieman
- Post-docs:
  Sam McKagan
  Linda Koch

Ph.D. students:
Wendy Adams
Jack Barbera
Kara Gray
Chris Keller
Pat Kohl
Noah Podolefsky
Aaron Svoboda
Chandra Turpen

School of Ed. collaborators:
Valerie Otero
Derya Cobanoglu
Danielle Harlow

Circuit Construction Kit (CCK)

- Part of *Physics Education Technology* project
- Build, manipulate, & test DC circuits
- Interactive feedback
- Current is explicitly modeled
- FREE!
- http://phet.colorado.edu



Research Questions

What happens when a simulation is used in lieu of real laboratory equipment?

- How do simulations affect students' conceptual development?
- What is gained and lost when students use a simulation?

Different Classroom Environments

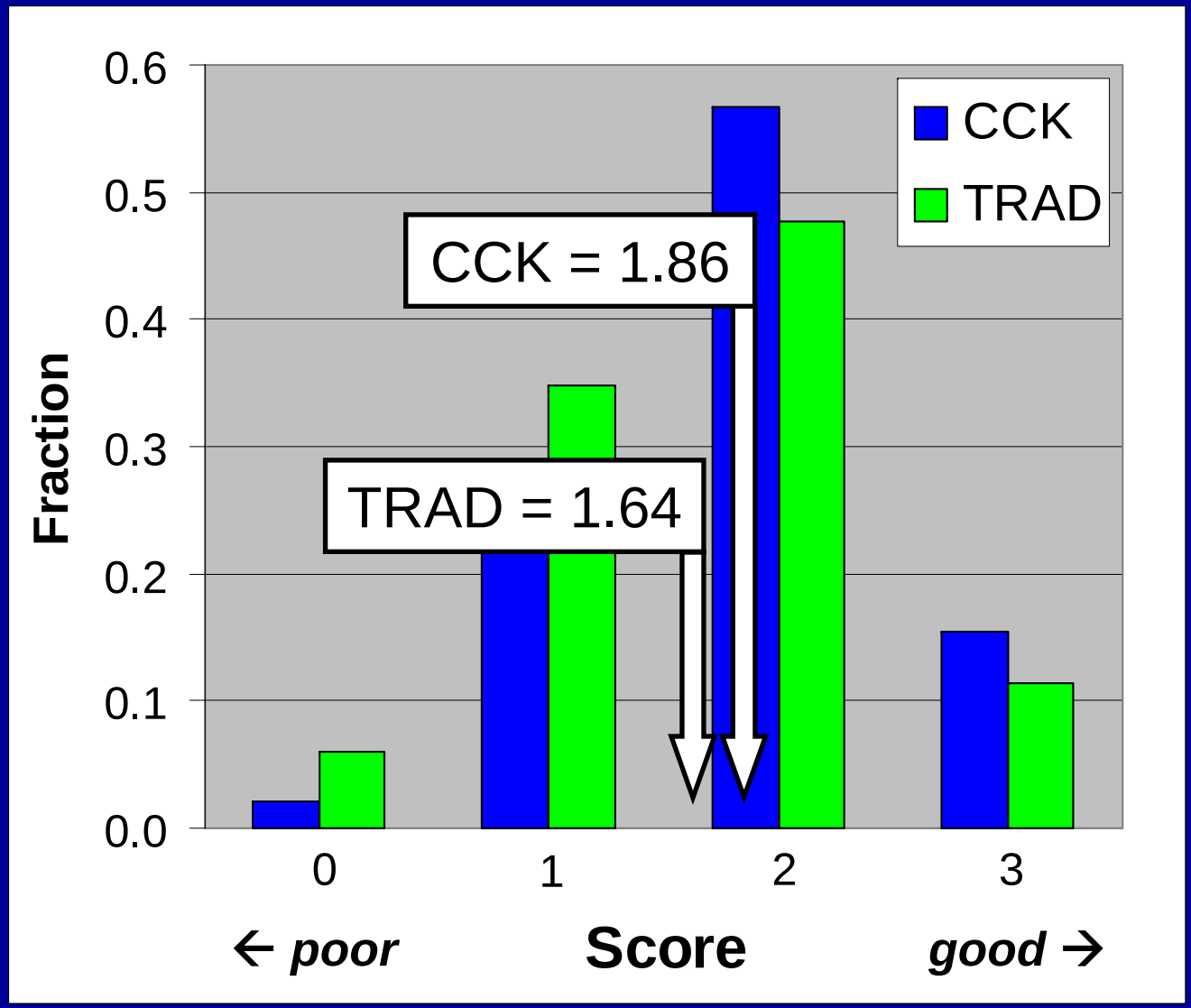
3 different college intro physics environments:

- Laboratory (algebra-based)
- Recitation (calculus-based)
- Interactive Lecture (calculus-based)

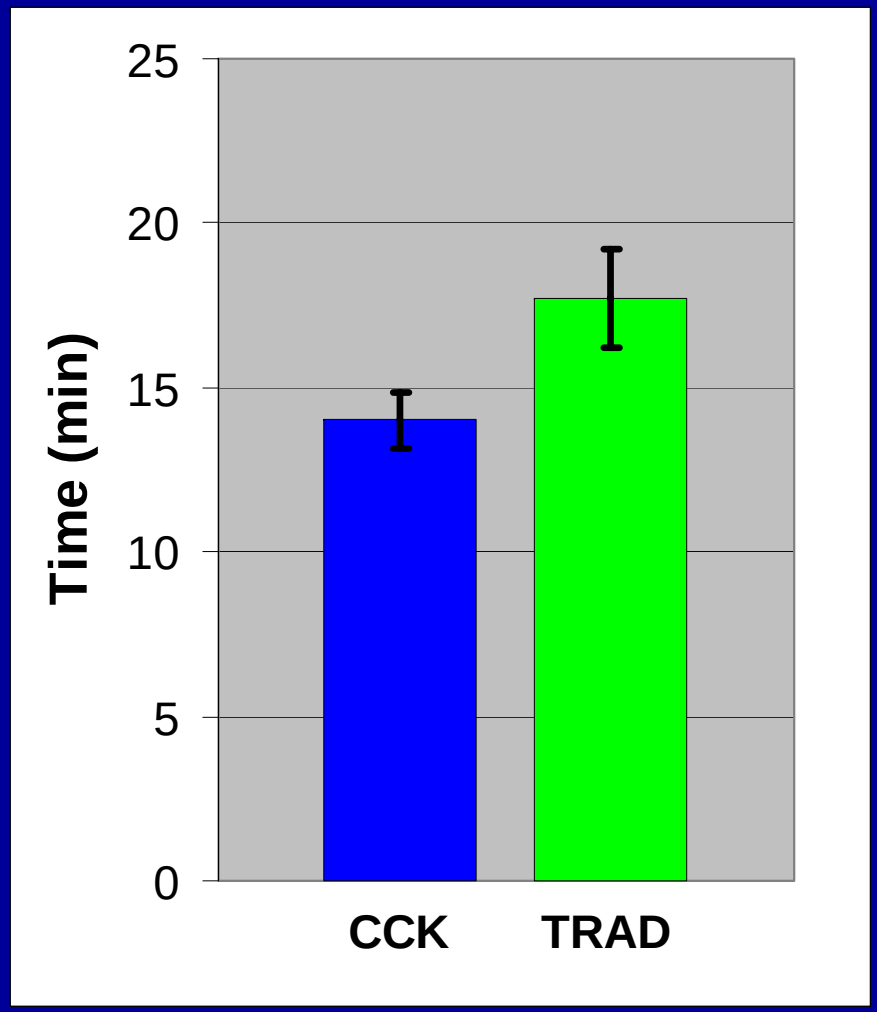
Traditional Laboratory

- Algebra-based, second semester
- DC circuits lab
  - CCK: 4 sections (N=99)
  - Real equipment (TRAD): 6 sections (N=132)
- Assessment
  - Challenge building real circuits and writing results

Evaluation of Write-up



Challenge Timing

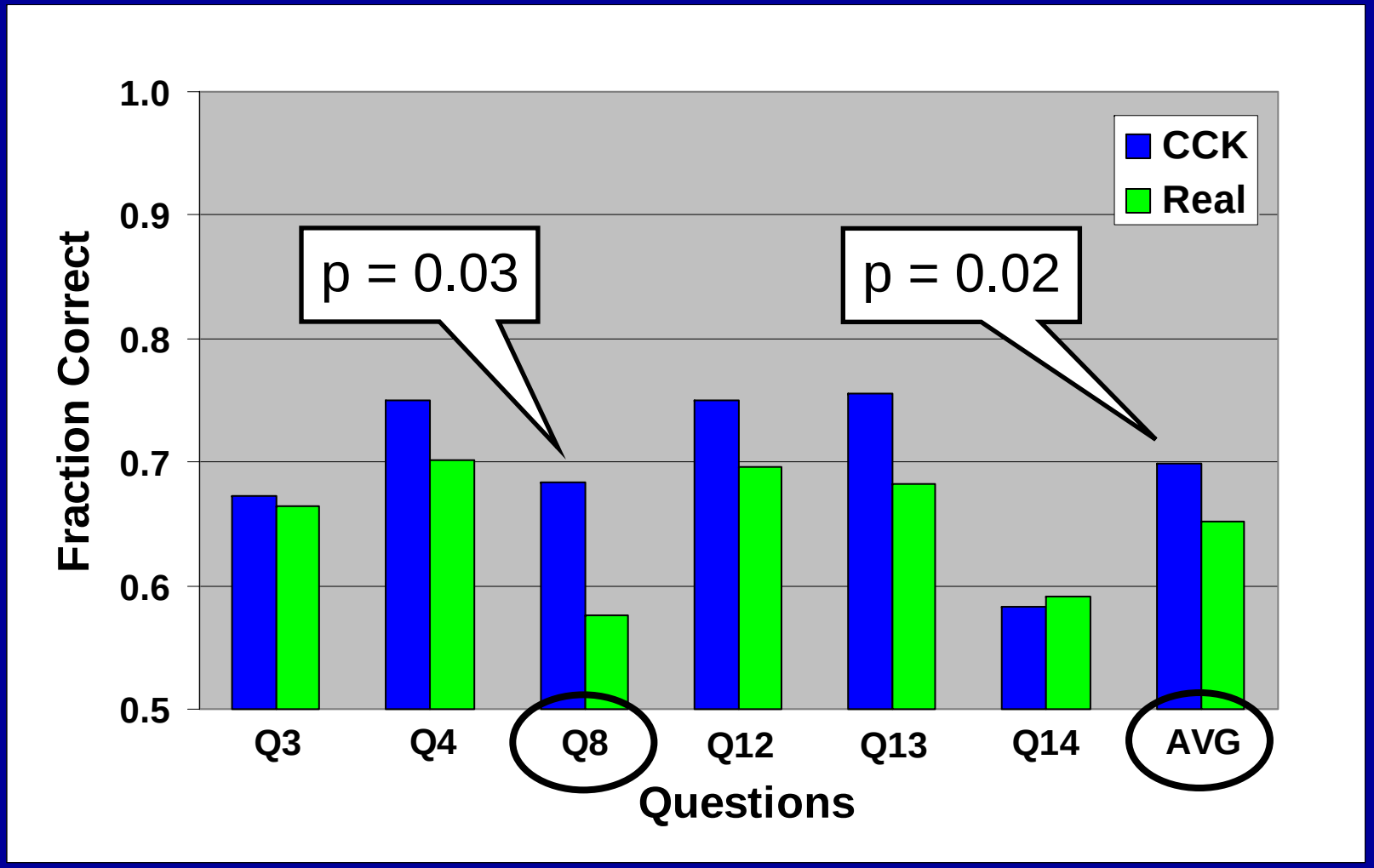


- Avg. CCK = 14.0 min
- Avg. TRAD = 17.7 min
- $p < 0.01$ (two-tailed t-test)

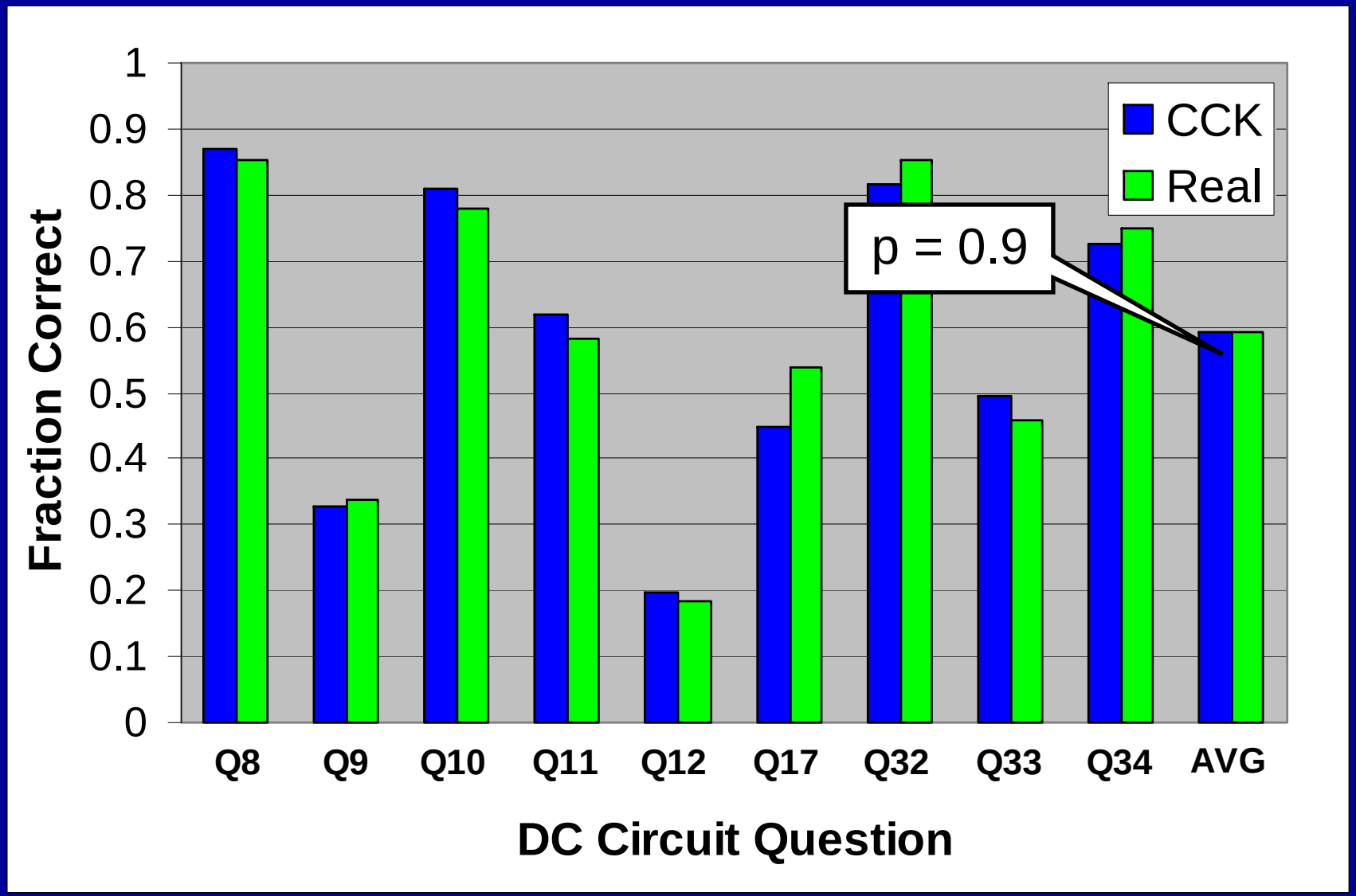
Recitation

- Calculus-based, second semester
- *Tutorials in Introductory Physics* (2 sessions on DC circuits)
  - CCK: 9 sections (N~160)
  - Real equipment: 9 sections (N~160)

DC Circuit Q's on Midterm



BEMA Data—End of Term

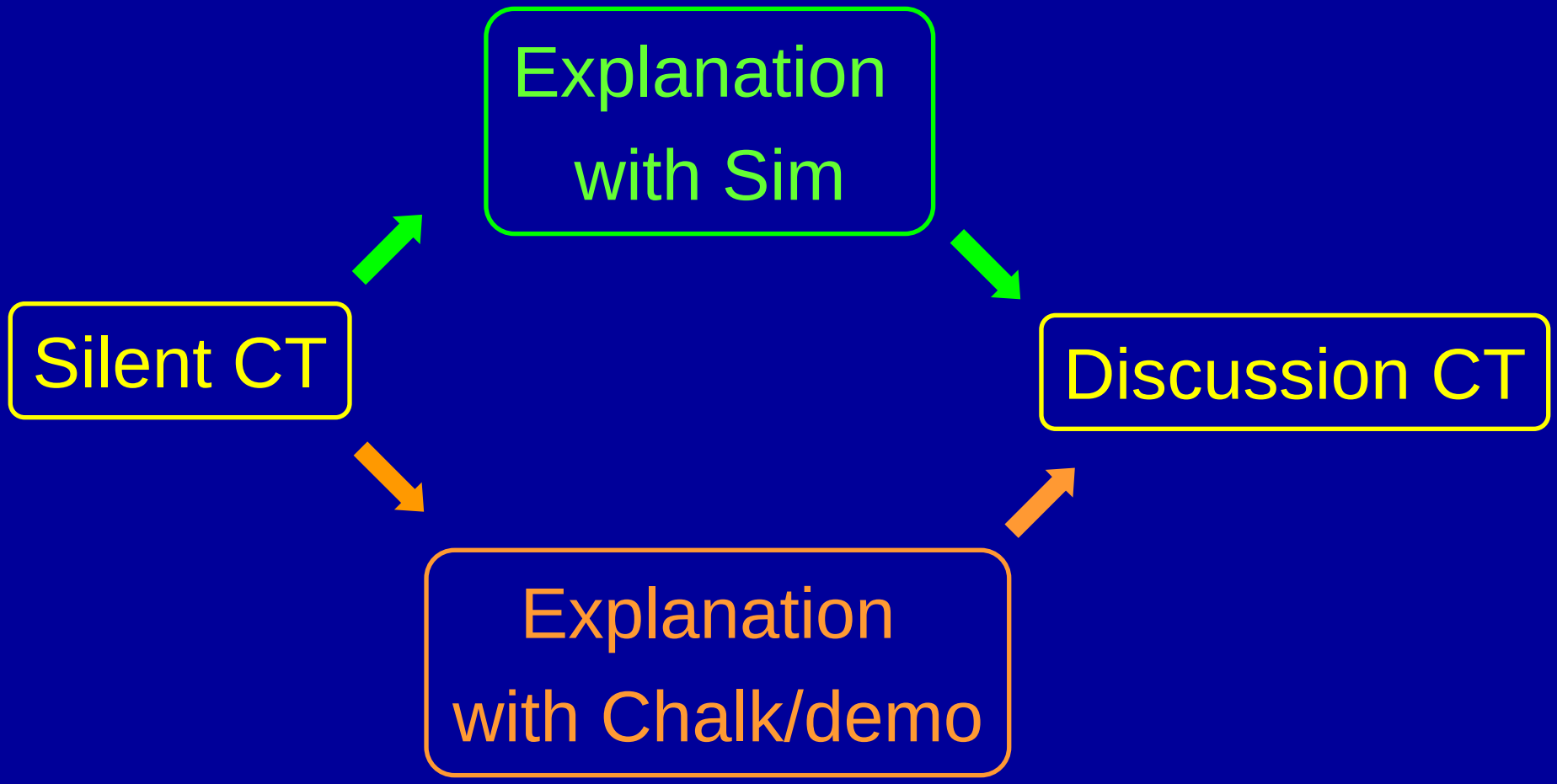


Lecture

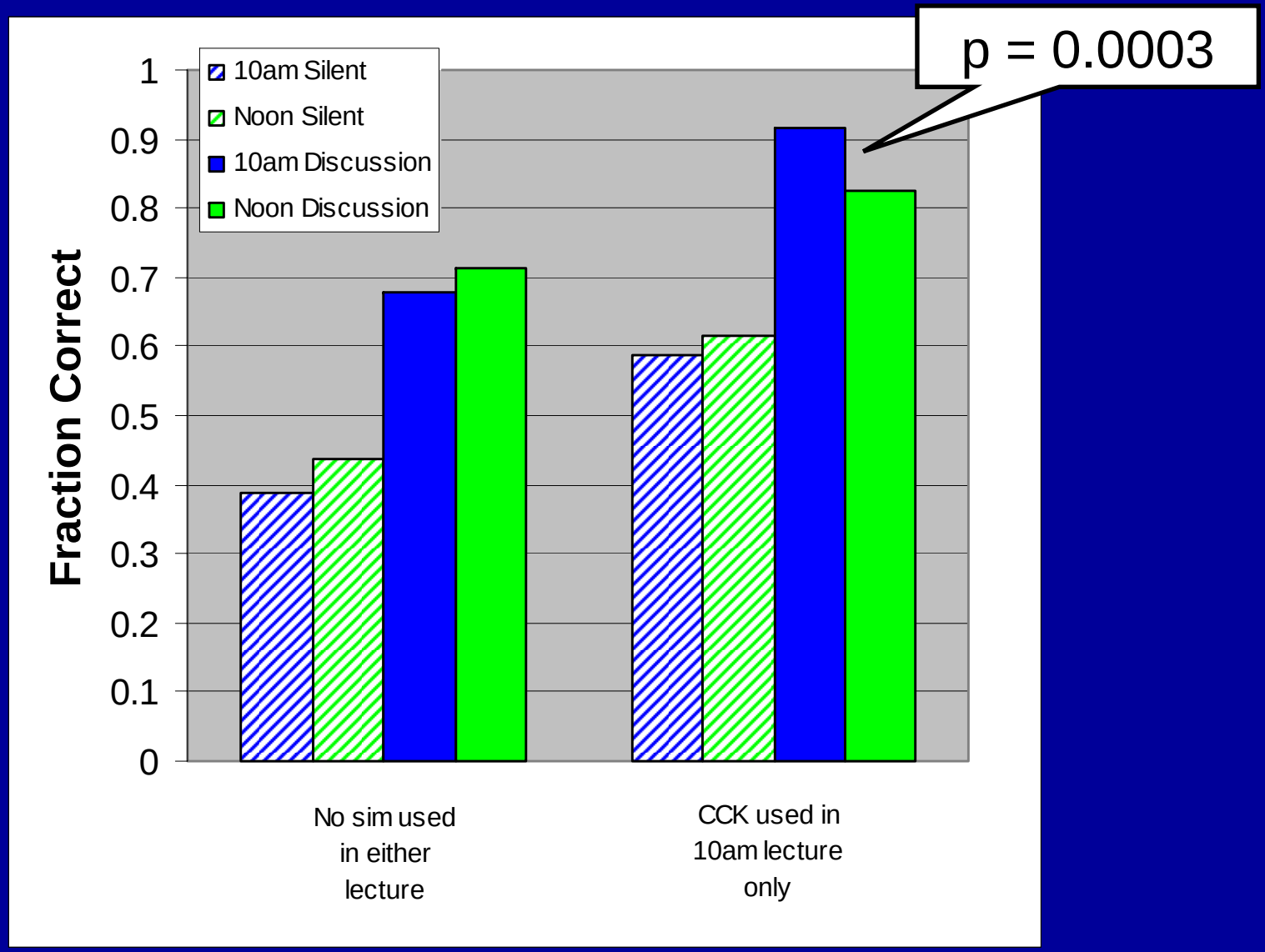
Can simulations help in lecture?

- Two separate, similar lectures (calc E&M)
- Compare: *sim+talk* vs. *chalk/demo+talk*

Silent/Discussion Method



Role of Sim with Peer Instruction



Conclusions

- Simulations can be successful:
  - In laboratory, recitation, and lecture
  - Depends on context (i.e., students, environment, sims, etc.)
- Simulations can promote the same or greater conceptual mastery
- Further studies in progress
  - Critical features of sims?
  - Critical features of the uses of sims?

Related Papers

- "When learning about the real world is better done virtually: a study of substituting computer simulations for laboratory equipment," N.D. Finkelstein, W.K. Adams, C. Keller, P. Kohl, K.K. Perkins, N. Podolefsky, S. Reid, R. LeMaster, Submitted to *Phys. Rev. ST - PER*, 2005.
- "Assessing The Effectiveness Of A Computer Simulation In Conjunction With *Tutorials In Introductory Physics* In Undergraduate Physics Recitations," C.J. Keller, N.D. Finkelstein, K.K. Perkins, S.J. Pollock, *PERC 2005*.

http://per.colorado.edu