Overview
We adapt research-based techniques known to be effective at the introductory level to an upper-division course.

We investigate student understanding of upper-division Electricity & Magnetism (E&M) through student interviews, homework, exams, and two research-based conceptual assessment tools. We compare student performance in a traditional and a transformed course.

All course materials and assessment tools are available online at www.colorado.edu/sei/departments/physics_3310.htm

What Changed?
Class blended traditional lecture with interactive engagement methods – not as dramatic a departure from the traditional approach as other transformation efforts[1,2]. Techniques included:

- Explicit course learning goals
- Interactive lecture style including whiteboards and kinesthetic activities
- Concept Tests (with clickers and peer instruction)
- Homework assignments that addressed the learning goals, including real-world contexts, sense-making, estimations.
- Weekly optional Socratic-style homework help sessions
- Weekly optional guided-inquiry Tutorials inspired in part by others[2,3]
- Conceptual and calculational assessment tools

The Courses

Traditional Course (N=41)
Instructor usually teaches upper-division courses by traditional lecture
Average student ratings of instructor: 90%/75% (upper- and lower- division)

Transformed Course (N=21)
Award-winning instructor usually teaches lower-division courses with PER techniques
Average student ratings of instructor: 97%/94% (upper- and lower- division)

Effect of Help Session Attendance
To investigate the effects of attendance at optional help sessions, while accounting for self-selection bias, we created a linear regression ($r^2 = 0.48$) to predict course grade from previous grades (see plot[4]). Students who went to many help sessions did not get higher grades than predicted by the model (data not shown).

Results & Conclusions

• An upper-division E&M course was transformed using principles of active engagement and learning theory.
• Students in the transformed course performed better on both traditional and conceptual assessments.
• We cannot yet differentiate between the effects of pedagogy and increased student contact with the material (through higher attendance and additional help sessions). This is an ongoing research project, including further development of course materials and assessment instruments.

References

Acknowledgements
We acknowledge the generous contributions of faculty at CU, including Dr. S. DeAlwis, Dr. T. DeGrand, Dr. D. DeWolfe, Dr. M. Dubson, Dr. N. Finkelstein, Dr. W. Ford, Dr. A. Hausenflurs, Dr. T. Manus, Dr. S. Parker, Dr. K. Perkins, Dr. C. Rogers, and Dr. C. Wieman, as well as the contributions of two undergraduate Learning Assistants, Wart Hanley and Darren Tansley, and the entire PER group at CU. Special thanks to Karen Joy for assistance with the regression analysis.

This work is funded by The CU Science Education Initiative and NSF-CCLI Grant #0537119.